THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XV., No. 3. 1889. Whole No. 50.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

QUICK'S PATENT PERFORATED CAKE POWDER FOR ORDNANCE.

By GEORGE QUICK, Fleet Engineer, R. N. (Retired).

During recent years many attempts have been made to increase the velocity of projectiles and at the same time to keep down the maximum pressure of the powder gas within the bore of the gun. It is evident that if the powder pressure is to be restricted, an increased velocity can only be obtained by causing the maximum pressure to act during a longer period, and over a greater space, on the projectile, and with this object the various slow-burning and cocoa powders have been produced, and tried with results which, though fairly successful so far as keeping down the pressure is concerned, can hardly be considered satisfactory, as the large amount of hot residuum left in the bore after firing has given rise to serious difficulties in reloading the guns, as well as causing danger of premature ignition on reloading.

Thus it is stated in "The extracts from the Proceedings of the Department of the Director of Artillery and the Ordnance Committee," that:

1. In 8-inch Armstrong B. L. gun, in which internal metallic tubes in cartridges were used: "The presence of molten residue in

the chamber when the breech was opened was very apparent on more than one occasion."

2. In 12-inch B. L. gun, Mark II, in which Rottwell Prism[3] powder was used: "At the commencement of the practice a couple of buckets of water were thrown into the gun after each round, to soften the fouling."

3. In 12-inch B. L. gun, Mark I, in which Cocoa powder was used: "Considerable delay was experienced owing to an accumulation of fouling in the chamber, and the shells had repeatedly to be tapped home."

4. In 12-inch B. L. gun, Mark I, in which Brown Prism[1] powder was used: "A scraper was used throughout for removing the residue."

5. Residuum from Rottwell and Cocoa powders: "With the Rottwell and Cocoa powders a large quantity of residue was left; it was so hot at first that it actually fired prisms of powder even when enclosed in a shalloon cover."

Nor are these Cocoa or Brown powders altogether satisfactory as regards uniformity of pressure, for we find from the above named "Extracts" that the Superintendent of Royal Gunpowder Factory states:

6. "He cannot account for the abnormal results which occur sometimes with all powders; for instance, it will be admitted that Rottwell Cocoa is a good powder, yet with the same projectile and the same sample of powder fired the same month, July, 1888, the results in the 10.4-inch B. L. gun were:

Charge, lbs.	Muzzle velocity, foot-secs.	Pressure, tons.
260	2213	22.35
240	2149	24.0

where the lower charge gave lower velocity but much higher pressure."

7. That the Superintendent of Royal Gunpowder Factory states also: "The results of experimental powders compared with P[3], Prism, and Cocoa, from which it will be seen that Cocoa powder has given very different results at different times—there being as much as 63 feet muzzle velocity and 3 tons pressure between different rounds with same charge and projectile—there is, apparently, a definite superiority over the best black powder."

(This remark refers only to black powder as usually made at the present time.)

Furthermore, these powders have been found to be very erosive in their action, this erosive action being due to the intense heat generated by them, as well as to the chemical constitution of the products of combustion. And in addition to this, it is still somewhat doubtful whether they do not deteriorate when kept for any considerable period in extreme climates. On the other hand, with the black powder, the fouling of the weapon after firing is much less than with any variety of slow-burning Brown or Cocoa powder yet produced, and it will perhaps be admitted that any method of rendering this black powder, the good qualities of which have been so long known, capable of giving high velocities with low pressures will be worthy of exhaustive practical trial.

At the same time it must be understood that the Quick method of forming the powder, or more properly "propelling material," is equally applicable to any of the new chemical combinations for propelling materials as to the ancient, saltpetre, charcoal and sulphur mixture.

Before entering into a description of the way in which this end has been attained in the Quick perforated cake powder, it may be advisable to take up some general considerations concerning the combustion of powder in the chamber of a gun.

Let p be the pressure of the powder gas, v its volume, and T the absolute temperature of the gas; then we have the well-known relation

$$pv = cT, \tag{1}$$

where c is a constant.

Now the velocity of the shot, other things being equal, is proportional to the square root of the work done by the powder gas. This work may be conveniently divided into two portions, viz., the work done during combustion, and the work done afterwards during expansion. But this latter portion we have, by analogy with steam and gas engines,

$$pv^n = p_0 v_0^n,$$

where p_0 is the pressure at the commencement of expansion, and v_0 the corresponding volume. The work done between the volumes v_0 and v_1 is given by the expression

$$U = p_0 v_0^n \frac{v_1^{1-n} - v_0^{1-n}}{1-n}. \tag{2}$$

Now v_1 is a constant, being the total volume of the bore less the space occupied by the solid products of combustion; also p_0 is a

constant, being the maximum pressure permitted in the bore; hence v_0 is the only variable occurring in the above expression. Experience shows that n invariably lies between 1 and 2, and hence the form of the expression shows that there is a certain value of v_0 which will make the work done in expansion a maximum. To determine this value, differentiate U with regard to v_0, and we obtain

$$\frac{dU}{dv_0} = \frac{p_0}{1-n}\left(n \times v_1^{1-n} \times v_0^{n-1} - 1\right) = 0$$

for a maximum, or

$$v_0 = \frac{1}{\sqrt[n-1]{n v_1^{1-n}}}.$$

By taking the second differential it is easily shown that $\frac{d^2U}{dv_0^2}$ is negative for the above value of v_0; hence U is a maximum for this value. Now without doubt most of the work done by ordinary grain powder in the bore is done during expansion, and hence this relation gives approximately the best ratio of v_0, the volume at the end of combustion, to the whole capacity of the gun. It will be interesting to obtain some idea as to the actual value of v_0, and for this n may be assumed as equal to 1.4, and from this we get

$$v_0 = 0.431\, v_1.$$

It is obvious that such a value would be difficult to obtain in practice, yet the more nearly it is approached the greater will be the velocity of the shot with a given maximum pressure, that is, provided the assumption that most of the work is done during expansion be fulfilled.

There remain two methods of increasing the value of v_0, the first being to increase the air-spacing of the charge by increasing the volume of the chamber, and the other is to make use of a slow-burning powder, which causes the projectile to move a sensible distance whilst combustion is proceeding, and it is in this direction that the best results are to be looked for.

The rate at which powder burns away is dependent upon a number of conditions. It varies, first, with the nature of the material from which, and the temperature at which, the charcoal contained in it has been prepared; second, with the amount of grinding or incorporation its constituents have undergone; third, with the amount of moisture it contains, and with the length of time and temperature of storing; fourth, with the density of the powder itself; and fifth, with

the pressure of the atmosphere of fire to which it is exposed. Neglecting the first four conditions, which do not vary during combustion, we may write, with Sarrau,

$$V = k\sqrt{p} \tag{3}$$

where V is the velocity at which combustion is taking place, k a constant, and p the pressure in pounds per square inch of the atmosphere of fire to which the charge is subjected. If we multiply the above velocity of combustion by A, the area of ignited surface, we shall obtain for weight of powder consumed at any instant the expression

$$W = a\int_0^t A\,V dt, \tag{4}$$

where a is a constant.

Referring back to equation (1), we may write it in the form

$$p = \frac{We\,T}{v}, \tag{5}$$

where W is the total weight of gas generated in a given time, v the volume it occupies, and e a constant. If we consider (as assumed by M. Sarrau, Engineer-in-Chief of the French Powder Factories) the solid material of the powder after burning to occupy the same space as the powder itself before ignition, this volume v is equal to the air-spacing plus the volume generated by the motion of the projectile up the bore, and may be written in the form

$$v = \omega(q + s),$$

where ω is the area of the bore, ωq the volume of the air-spacing, and s the distance moved by the projectile.

Now T may be taken as constant during the whole period of ignition, and we then have

$$p = \frac{We\,T}{\omega(q + s)}, \tag{6}$$

and combining with (4) we get

$$p = \frac{e\,T}{\omega(q + s)}\,a\int_0^t A\,V dt. \tag{7}$$

With most powders, A, the area of combustion surface, decreases as t (the time) increases, and we will therefore write

$$A = A_0(1 - \beta t),$$

where A_0 is the area of the initial ignition surface, from which we get

$$W = aA_0 \int_0^t V dt - a\beta \int_0^t t V dt.$$

The object to be arrived at is that p shall very rapidly reach the value p_{max}, which shall be maintained constant till the completion of combustion, hence the curve of pressure should be of the shape shown in Fig. 1 by *aaab*.

The period of combustion itself may be conveniently divided into two parts: first, that in which the maximum pressure is being attained, and secondly, that in which it is being maintained.

The work done on the projectile during the first portion is approximately

$$\tfrac{1}{2} p_{max} \omega s,$$

which will be equal to the energy of the shot, or

$$s' = \frac{ds}{dt},$$

$$m(s')^2 = p\omega s,$$

$$s' = \frac{p_{max}^{\frac{1}{2}}}{m^{\frac{1}{2}}} \cdot \omega^{\frac{1}{2}} s^{\frac{1}{2}},$$

or
$$\frac{ds}{s^{\frac{1}{2}}} = \frac{p_{max}^{\frac{1}{2}}}{m^{\frac{1}{2}}} \cdot \omega^{\frac{1}{2}} dt,$$

or
$$2s^{\frac{1}{2}} = \frac{p_{max}^{\frac{1}{2}}}{m^{\frac{1}{2}}} \omega^{\frac{1}{2}} \int_0^t dt,$$

or
$$s = \frac{1}{4} \cdot \frac{p_{max}\, \omega}{m} t^2,$$

where m is the mass of the projectile; and as t shall be very small, s may be neglected, together with the work done during the rise of pressure.

Turning to the second period of combustion, if $p = p_{max}$ throughout, we should have

$$s = \frac{1}{2} p_{max}\, \omega \cdot \frac{t^2}{m},$$

and the volume generated by the projectile is

$$\omega s = \frac{1}{2} \frac{p \omega^2 t^2}{m},$$

and
$$p = \frac{We\, T}{\omega (q + s)},$$

$$= \frac{WeT}{\omega\left(\frac{1}{2}\frac{p\omega}{m}t^2 + q\right)}. \qquad (8)$$

Further $$W = aA_0\int_0^t Vdt - a\beta A_0\int_0^t tVdt.$$

But as p is to be constant throughout the time t, V will also be constant; hence

$$W = aA_0V\left(t - \frac{\beta}{2}t^2\right),$$

and

$$p = \frac{aA_0VeT\left(t - \frac{\beta}{2}t^2\right)}{\omega\left(\frac{p\omega}{2m}t^2 + q\right)}.$$

Now if p is to be constant it should be independent of t; but unless β is negative, the two curves $\left(t - \frac{\beta t^2}{2}\right)$ and $\left(\frac{p\omega}{2m}t^2 + q\right)$ will have opposite curvatures, and this condition cannot then be approximately complied with. If, however, we give β this negative sign so as to make the surface increase as combustion proceeds, at the same time making q, which is a measure of the air-spacing, and A_0, the initial ignition surface, small, we can make p nearly independent of the time, that is to say, it may be kept approximately constant during the time combustion is proceeding. This condition cannot, however, obtain with powders in which the surface of combustion decreases as with those commonly used. It is easy to see that an exact solution of the problem of keeping the pressure constant during combustion is impossible, but we can obtain a practical approximation to it, as described below.

Suppose a cylindrical block of powder h inches high and d_2 inches diameter outside. Let it be pierced with a hole of diameter d_1, then its surface will be

$$s_1 = \pi h(d_2 + d_1) + \frac{\pi}{2}(d_2^2 - d_1^2).$$

Let it be burned away uniformly to a depth a. The area of the surface then is

$$s_2 = \pi(h - 2a)(d_2 + d_1) + \frac{\pi}{2}\left[d_2^2 - d_1^2 - 2a(d_2 + d_1)\right],$$

which is always less than s_1.

Hence the surface is decreased as combustion proceeds, and hence no such system of forming powder can give the best ballistic results.

If, however, in addition to the hole through the center of the block, there are a number of smaller ones ranged round it, as shown in Fig. 2, it will be possible to keep the surface from diminishing as combustion proceeds, and it may even be increased. For example, let there be n of these smaller holes of diameter d. Then the surface at the commencement is

$$s_1 = h\pi(d_1 + d_2 + nd) + \frac{\pi}{2}(d_2^2 - d_1^2 - nd^2).$$

And when burned to a depth a, the surface is

$$s_2 = \pi(h - 2a)(d_2 + d_1 + nd + 2na) + \frac{\pi}{2}[d_2^2 + d_1^2 + nd^2 - 2a(d_2 + d_1 + nd) - 4na^2].$$

Hence

$$s_2 - s_1 = 2a\pi[hn - 2(d_2 + d_1 + nd) - 3na],$$

which can evidently be made positive by taking h sufficiently large.

In Figs. 2 and 3, showing the Quick cake powder, it will be observed that alternate quadrants of the cake are in relief, so that when two cakes are placed together, the raised quadrants of the one fit into the sunk ones of the other, and the two cakes are in a manner locked. Moreover, the quadrants are dished, or somewhat hollowed out towards the center, as shown, to permit the flame readily reaching the whole surface of the cakes. A cartridge is formed from a number of these cakes placed together, which may be united by means of a waterproof cement, which is highly combustible, and which leaves only a very small amount of residuum, namely, about a quarter of one per cent.

The disposition of the air-spacing here adopted permits the ready flow of the gases to the base of the projectile, which is not the case when powder of the ordinary form is employed. With the latter, when long cartridges are ignited from their rear ends, the gas pressure then generated ruptures the powder in front, crushing it probably into very small fragments—whereby the velocity of combustion is increased—thus causing excessive local or so-called "wave" pressures, which may injure the gun.

Large air-spacing is an expedient adopted for the purpose of mitigating the evils arising from powder improperly ignited and improperly consumed. This large air-spacing has always largely diminished the efficiency of the powder, fewer tons of energy being obtained per pound of powder than when the air-spacing is small. But as this

aaab is a speculative diagram, showing pressure due to the combustion of powder with a considerable amount of solid or liquid residuum without heat.

aaac is a speculative diagram, showing pressure due to the combustion of powder which leaves no residuum.

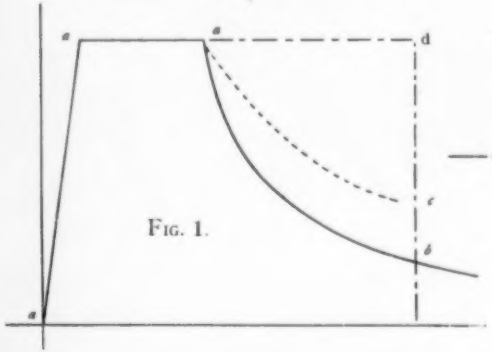


FIG. 1.

aaad is a speculative diagram, showing pressure due to the combustion of an imaginary perfect propelling material.

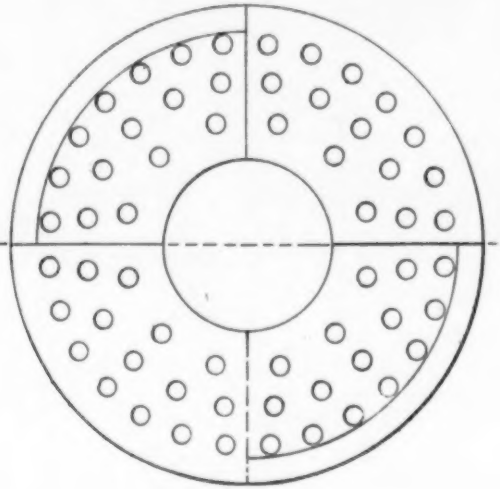


FIG. 2.

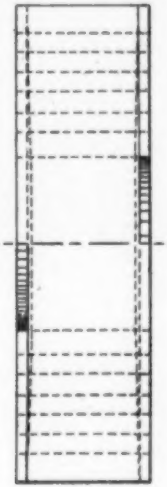


FIG. 3.

To face page 414.

large air-spacing enabled heavier charges to be used without dangerously high pressures being generated, it had a certain amount of utility, although it necessarily added to the weight of the gun and to the size and weight of the breech mechanism.

Now with this form of perforated cake powder we can use a much higher gravimetric density of charge, get a larger amount of energy per pound of powder, and obtain a higher velocity with lower pressure, whilst at the same time we can reduce the diameter of the breech of the gun and reduce the size and weight of the breech mechanism.

In the following comparison of 6-inch guns the dimensions are kept the same for all these guns as far as possible, so that any variation of strength shall be due entirely to the size of the chamber and the external diameter of the gun only, and not to variations in the diameter of the A-tube and breech-piece.

In the following comparison:

D_3 = diameter of exterior of gun over chamber.

D_2 = diameter of breech-piece.

D_1 = diameter of A-tube.

D = diameter of chamber.

$$R_3 = \frac{D_3}{2}.$$

$$r_3 = \frac{D}{2}.$$

Comparison of 6-inch guns of similar construction but of different diameter of chamber and different external diameter:

No. 1 gun, $D_3 = 23''$, $D_2 = 16''$, $D_1 = 11''$, and $D = 8''$.
" 2 " $D_3 = 23''$, $D_2 = 16''$, $D_1 = 11''$, " $D = 7''$.
" 3 " $D_3 = 22''$, $D_2 = 16''$, $D_1 = 11''$, " $D = 8''$.
" 4 " $D_3 = 22''$, $D_2 = 16''$, $D_1 = 11''$, " $D = 7''$.
" 5 " $D_3 = 21''$, $D_2 = 16''$, $D_1 = 11''$, " $D = 7''$.

No. of gun.	Dimensions R_3 and r_3. Inches.	Volume per in. of length of chamber. Cubic inches.	Strength of chamber, all steel being taken at 15 tons. Tons.	Strength per cubic inches of metal of chamber. Tons.	Volume of metal required per ton of strength. Cubic inches.
1.	11.5 4.0	365.25	20.88	0.0571	17.49
2.	11.5 3.5	377.0	24.03	0.0637	15.68
3.	11.0 4.0	329.86	19.84	0.0604	16.61
4.	11.0 3.5	341.6	22.91	0.067	14.9
5.	10.5 3.5	307.88	21.667	0.0703	14.2

Thus comparing No. 1 gun with No. 4 gun, we see that we may use 10 per cent (or exactly 9.72 per cent) more pressure in No. 4 gun than in No. 1 gun; whilst as regards weight per inch length of chamber, the No. 4 gun will be 6.3 per cent less in weight (or No. 1 gun is 6.92 per cent heavier than No. 4 gun), although the thickness of the wall of the chamber is the same in No. 4 gun as in No. 1 gun. Or if we make a gun of 21 inches diameter we have a gun of 0.787 ton greater strength than No. 1 gun, and 15.7 per cent less weight (or No. 1 gun is 18.6 per cent heavier than No. 5 gun) per inch of chamber length.

Of course, with the chambers of small diameter a greater length of chamber would be required to contain the same charge of powder with the same density of loading, that is, with the same amount of air-spacing, and greater length of chamber would add to the weight of the gun somewhat. But, as the gun with small chamber would be stronger, a higher gravimetric density may be employed, so that the total volume of the chamber would be less, provided that the charge be properly ignited in the first place, and the powder converted at a uniform or increasing rate into gas. The central air-spacing and the form of the cakes of the "Quick" powder insure this necessary instantaneous ignition and complete combustion of the whole charge at a uniform or increasing rate.

With regard to the maximum pressure to be adopted for the powder gas in the gun, this is a question to be settled by practical experience rather than by speculative deductions. It would appear that a pressure of 20 tons per square inch should not be exceeded, and one considerably lower will probably be found to give the best results. If higher pressures are employed, there appears to be great danger of reaching, at the high temperature at which the powder burns, the temperature of fluidity of the metal of the bore, in this way increasing erosion. It is well known that iron and steel at high temperatures are porous to many gases, and it is not unlikely but that with high pressures and very high temperatures combined, a not inappreciable quantity of the gases produced may be forced into the metal, so that there would occur a larger loss of energy from the cooling action of the surface of the chamber and bore, with increased heating and possible deformation of the gun, than with gases of lower pressure and less temperature. It seems probable that some action of this kind must occur, as it is otherwise difficult to account for the observed facts that high pressures are

frequently associated with low velocities. In addition to this loss of energy, this penetrative action of the gases will effect a change in the molecular condition of the metal, by which it will be deteriorated, which deterioration will tend to increase erosion as firing proceeds.* From these conditions it would appear that the maximum pressure to be admitted is not merely a simple question of thermodynamics, as is sometimes considered, but is limited by the physical condition of the metal of the gun, besides the mere tensile strength thereof.

It is but an evident truism to say that the more work the powder does on the gun, the less work can it do on the projectile, and conversely, that the more work that is done on the projectile, the less work and the less wear, tear and injury will be done on the gun.

Here it may be remarked, that by constructing the powder for heavy guns on the principles stated above, the rise of pressure in the bore can to a very large extent be effectively controlled by suitably arranging the initial ignition surface, the density of the cake-powder, the air-spacing, and the form of the cakes, so as to give a nearly uniform or increasing combustion surface. It would therefore appear that such a powder is peculiarly suited to firing large projectiles of thin metal charged with high explosives, and the final solution of a satisfactory dynamite gun is certainly to be found in this direction, as the pneumatic type is open to many grave practical objections as to its length, the cumbrousness of the machinery required for manipulating it, and the want of accuracy in such high-angle fire.†

The conclusions which have been arrived at above may be summarized as follows:

1. The pressure should, if possible, be maintained at its maximum till the projectile has traveled some considerable distance up the bore.

2. This can be most satisfactorily obtained by using a powder

* The enormous gas friction which Mr. Longridge states (see his letter in *Engineering*, May 4, 1888) to exist in the bore of guns, must be aggravated more by the high pressures he advocates than by the small increase in the weight of the residuum due to any slight increase in the weight of the charges of large-sized or slow-burning powders giving moderate pressures.

† In the foregoing remarks it has been assumed that the perforated powder cakes will not break up to the smallest extent during the period of combustion in the chamber of the gun. It should be needless to say that it is not expected that this assumption will be found mathematically true in practice, but that it is true enough for all practical purposes has been proved by the experiments which will be referred to later on.

whose surface of ignition increases as combustion proceeds, or remains practically uniform.

3. That a comparatively low maximum pressure should be adopted, if the best results, in the fullest sense of the term, are to be obtained.

4. That the density of the powder should be very high, so as to secure uniformity of combustion, and that the initial ignition and terminal combustion surfaces should be large enough to secure a sufficiently rapid combustion of this very dense and slow-burning powder, so that none may be blown out of the gun in an unconsumed state.*

* Noble and Abel, *Researches*, page 131, state that the time occupied by the projectile in moving 1 foot is about 0.005 second. Consequently, as the powder can be burnt entirely in this time, the maximum pressure can be kept up whilst the powder is burning, if the powder burns with increasing velocity, but it certainly cannot be with fine-grain powder, which is all ignited at once. See also Sébert and Hugonist, "Experiences with 10 cent. Gun," which shows that with the rotating ring of the projectile fitting the bore, the maximum pressure—1400 atmospheres—was generated in 0.004 second; whilst with the *same* charge of the *same* powder, but with the rotating ring in its normal condition, the maximum pressure—2400 atmospheres—was reached in 0.001 second. From the experiments of Sébert and Hugonist it is seen that by the great resistance of the rotating ring of the projectile on taking the rifling, the pressure of the powder gas is increased from 1400 atmospheres per square centimeter to 2400 atmospheres. This is due to the resistance of the projectile giving sufficient time for the whole of the powder grains to be ignited before a moderate motion of the projectile took place, because there was no possibility of the gas first generated acting directly on the base of the projectile to put it into motion. The resistance of the rotating ring of the projectile, by increasing the pressure of the gas beyond the point due to the mere inertia of the projectile (namely 1400 atmospheres), increased the velocity of the combustion of the powder in the proportion of nearly 3 to 4 (or more correctly $\sqrt{1400} : \sqrt{2400} = 3 : 3.92$), if we accept Piobert's theory on the velocity of combustion under pressure. The powder used in these experiments was the Sevran-Livry powder of density 1.81, the least thickness of the grains being 0.5 inch, the number of grains to the pound being about 49. Now it is very certain that we must retain the rotating ring in its normal condition for ordinary use, and the question arises, how can the projectile with the normal rotating ring be used so that the maximum gas pressure shall not rise to so great a height (the difference between 16 tons per square inch and 9.4 tons being immensely in favor of the rotating ring being made to fit the bore). From experiments that have been made, it appears that in small guns of 3 to 5 inches caliber, the hydraulic pressure required to push the ordinary rotating ring into the rifling is about 1 ton per square inch of the cross section of the projectile. If, then, at the moment of initial ignition of the charge, the gas pressure can

5. That the air-spacing should be reduced to the lowest possible amount compatible with the due ignition of the charge, and with a sufficient channel space to allow of a fair flow of the powder-gas direct to the base of the projectile as soon as the charge is ignited.

6. That the powder-charge should be so arranged that the whole of it should be simultaneously ignited, in order that each and every element (cake) should be surrounded by an atmosphere of fire equal in pressure in all directions.

It is desirable to consider some practical application of the principles before stated, and to give some examples of the manner in which different descriptions of powder burn, and some results which have been obtained with the perforated cake powder in the Quick B. L. gun of 3-inch bore.

The following is a statement of the area of the combustion surface of 42-pound charges for a 6-inch gun, the charges being of various powders:

a. 42-pound charge of 1.5-inch cubes of powder, averaging 6 to the pound, P_3 powder, density 1.75.

b. 42-pound charge of hexagon powder, .976 inch high, 1.367 inch over sides, with 1-inch central perforation, .394 inch diameter, prism[2] powder, density 1.75.

c. 42-pound charge of Quick perforated cake powder, 6.7 inches diameter, thickness or length on axis 1.7 inch, with central perforation 2.5 inches diameter, and 60 other perforations .25 inch diameter, density 1.75.

d. 42-pound charge of Quick perforated cake powder, 7.7 inches diameter, thickness or length on axis 1.75 inch, with central per-

have free and direct access to the base of the projectile, it is evident the projectile should begin to move the very instant the gas pressure reaches or exceeds one ton per square inch. Now, by virtue of the air-spacing in the center of the Quick cake powder and cartridge, the gas has direct access to the base of the projectile, and therefore begins to push it into motion as soon as the pressure rises to or above 1 ton per square inch. And as the combustion proceeds, so the perforations in the powder increase in area, giving a larger and freer access of the gas pressure to the base of the projectile, so that as the projectile is constantly moving away, the pressure cannot rise very high. Hence the work of the gas is done, by virtue of the air-spacing, directly on the projectile, instead of being wasted in crushing up the powder and distending or otherwise injuring the metal of the gun.

The central air-spacing in the Quick powder admits of the whole charge being uniformly ignited, which is not the case when paper or metallic tubes are employed in the center of a cartridge of grain powder.

foration 1 inch diameter, and 72 other perforations .3 inch diameter, density 1.75.

e. 42-pound charge of Quick perforated cake powder, 7.7 inches diameter, thickness or length on axis 1.75 inch, with central perforations 2.5 inches diameter, and 33 other perforations .25 inch diameter, density 1.80.

Then assuming that all these powders are of uniform quality and density, except charge *e*, their rate of combustion under any given pressure will be the same, and we shall find that in the case of *a* the initial ignition surface will have an area of about 3400 sq. inches. When half the weight of the charge has been consumed (that is, converted into gas), the surface of combustion will be only 2130 sq. inches in area, and this area will diminish until zero is reached. Thus (1) at the instant when the projectile is without motion and tightly sealing the bore of the gun, the gas-generating surface of the powder is at a maximum. (2) When half the powder has been consumed and the projectile has acquired a certain velocity and has moved a considerable distance up the bore, the gas-generating surface is reduced about 38 per cent. (3) The gas-generating surface will rapidly diminish after this; and as the pressure of the atmosphere of fire in the bore falls also as the shot travels towards the muzzle, so will the velocity of combustion due to the pressure of the atmosphere of fire also decrease, so that it is highly probable that some of the powder will be blown out unburnt.

If we now consider the *time* of combustion of this form of powder, and assume that a thickness of .4 inch of solid powder will be burnt in 1 second of time under atmospheric pressure, then we shall have for the time during which this 1.5-inch cube is burning 1.875 second. (The actual velocity of combustion at the atmospheric pressure is about .4 inch per second; but at the usual pressure of the atmosphere of fire in large guns, M. Castan estimates that the mean velocity of combustion is about 32 times greater, that is, 12.8 inches per second.) The law assumed by de St. Robert, Castan, and Sarrau, that the velocity of combustion of powder varies as the square root of the pressure of the atmosphere of fire, may be true of very dense hard powders, and may be altogether inaccurate as regards powder of less density and greater porosity. It is highly probable that the velocity of combustion of porous powders of low density will be very much greater, owing to the flame being driven into the pores of the powder by the higher pressures of the atmosphere of fire. Again, the law assumed by Piobert, that the velocity of combustion varies inversely

as the square root of the density of the powder when burnt under the same pressure, may be true when the powder is burnt under atmospheric pressure only, but may be totally untrue when burnt under higher pressure; the velocity of combustion rising much more rapidly than inversely as the square root of the density when low density powders are burnt under high pressures.

Then, although every cube in the whole charge may have been ignited simultaneously, we shall find that when half the time of combustion has expired, the area of combustion-surface will be only 850 square inches, the weight of powder burnt during the first half of the period of combustion being 37.29 pounds, and in the last half of the period only 4.71 pounds of powder remain to be burnt.

But we know that in charges of this kind of powder, simultaneous ignition does not take place, as the rear of the charge is first ignited.

Repeating these calculations for the other charges of powder and placing them in tabular form (as on the next page), we can compare the results; the velocity of combustion being calculated for the pressure of the atmosphere of fire in which the combustion is effected.*

Description of charge.	Length of charge. Inches.	Area of initial ignition surface. Sq. ins.	Area of combustion surface when half the weight of the charge has been consumed. Sq. ins.	Area of combustion surface when half the time of combustion has expired. Sq. ins.	Area of combustion surface at the instant of final dissolution. Sq. ins.	Half of least thickness of powder pellet or cake burnt through. Inches.	Time for complete combustion of charge at atmospheric pressure, assuming the whole to be ignited simultaneously. Velocity of combustion $o''.4$ per sec. Seconds.	Velocity of combustion of charge at pressure due to the area of the initial ignition surface. Inches per sec.	Time for complete combustion of charge under pressure proportional to area of the initial ignition surface. Sec.	Weight of powder charge burnt during the first half of the period of combustion. Lbs.	Weight of powder charge to be burnt during the second half of the period of combustion. Lbs.
a	26	3400	2120	850	0	.75	1.875	19.05	.03936	37.29	4.71
b	26	3995	2960	2730	300	.24325	.6081	20.4	.01192	25.37	16.63
c	26	2580	2930	2860	2920	.2	.5	16.59	.01205	15.2	26.8
d	20	2600	3140	3010	3150	.2	.5	16.6	.01205	15.65	26.35
e	21	2178	2172	2240	1813	.35	.887	15.25	.02292	20.6	33.9

* It is proper here to remark that the employment of solid cakes of powder (*i. e.*, without perforations) was first proposed by Dr. Doremus, an American, but the results obtained were most unsatisfactory. The problem of making powder of such a form that its area of combustion-surface should be practically a constant was first taken up by the writer in 1870.

From these results* we can see that the initial ignition-surface of the Quick cake powder *c* is about 24 per cent less than that of *a* and 35.5 per cent less than that of *b*, and that the gas-generating surface of the Quick cake powder is at a maximum when the resistance of the projectile is at a maximum. Also that whereas the gas-generating surface, and consequently the gas generation, falls rapidly in the charges *a* and *b*, in the case of *c* and *d* the gas generation steadily increases as the projectile rushes up the bore.

We must then pursue our investigation as to the *time* of combustion of the powder, and ascertain the amount of powder which will have been burnt at the instant when half the time of combustion has expired, assuming as at page 420 that 0.4 inch of powder is burnt through at atmospheric pressure in 1 second, that is, that a 1.5 inch would occupy 1.875 second in burning. (See results in Table I.)

From these results we find that with the Quick cake powder we can obtain a progressive powder although the density may be very high and uniform throughout, and the quality uniform. And it is submitted that this form of powder possesses great advantages over the Fossano and other so-called "progressive" powders. It is also beyond question that a larger amount of energy has been obtained per pound of black powder than has been obtained per pound of any other cannon powder, when fired under the same conditions. And by the large reduction of air-spacing which the Quick form of powder permits, a very much higher efficiency will be obtained than has ever been the case hitherto.

Thus, in the record of experiments with the Quick experimental 3-inch B. L. gun, we find in round 29, where the air-spacing was small, due to the size of the chamber (145 cubic inches), giving 26 cubic inches per pound of powder, the efficiency of the powder was 71 foot-tons; whereas, in round 79, after the volume of the chamber had been increased to 180 cubic inches—giving 36 cubic inches per pound of powder—the efficiency of this 5-pound charge of black cake powder was only 56.6 foot-tons per pound of powder.

Now an absolutely perfect propelling agent (which of course is only imaginary) would be a material which would occupy say one-thousandth part, or less, of the length of the bore of the gun (no chamber being required), which material should give off such a volume of permanent gas (without color, smell, or active chemical properties)

*The details of the Quick experiment 3-inch B. L. gun, with some of the results obtained, will be found at the end of this paper.

at such a rate as would give a uniform pressure of, say, 15 to 20 or 30 tons per square inch throughout the whole length of the bore of the gun, the temperature of the said gas not exceeding, say, 500° to 1000° Fah. Such a propelling material we certainly have not at present, nor is there any prospect of its being obtained.

Such a propelling material would then require that the guns should be of the same strength from breech to muzzle—that is, they must be cylinders of the same diameter throughout—which would give the lightest and shortest ideal gun for obtaining any given effect.

Now, although we have not this ideal propelling material, we have the black powder material which, so far, has been proved to give a greater amount of ballistic energy per pound weight than any of the brown materials, when fired under the same conditions. (The disadvantage of the black powder material has been that it has given higher pressures than the brown material, but we need not refer further to that point at present.)

Now, by the perforated cake formation of the black material it has been proved that we get these advantages:

1st. That the complete ignition of the whole charge, however long, is effected simultaneously.

2d. That we can get either a uniform or an increasing area of combustion, and consequently a very uniform pressure during the whole time of combustion.

3d. That the pressure and ballistic effects of a given weight of this black powder are far higher than a similar weight of brown cake powder will give under the same conditions.

For from the experiments of June, 1887, with the Quick 3-inch B. L. gun, in round 28 we obtained an observed velocity of 2000 feet with 12-pound projectile and 5.56 pounds of black cake powder of 1.77 density, and a pressure which did not exceed 14 tons per square inch. In round 29 we obtained an observed velocity of 2145 feet with 12-pound projectile and 5.51 pounds of black powder of density 1.75, with a pressure of 14.05 tons. In round 41 we had an observed velocity of 2011 feet with 12-pound projectile and 6 pounds of black cake powder of 1.71 density, and a pressure of 16.8 tons per square inch, which, comparing with the foregoing rounds, shows that this lighter, quicker-burning powder, whilst giving a higher pressure, gave a less velocity than the smaller charge of higher density powder used in round 29. This result indicates that the density of the powder was too little for the weight and resistance of the shot and for the size and strength of the gun. In round 28, the density being higher

again than in round 29, the pressure was slightly lower and the velocity considerably less, showing that the density of the powder was too high for the weight and resistance of the shot and for the length of the gun, the efficiency of the powder per pound being 63.4 foot-tons. The round 29 shows that the density of the powder gave such a rate of combustion as to give probably the maximum results for the particular weight and resistance of the shot and for the length of the gun, the efficiency of the powder being 71 foot-tons per pound of powder. Turning now to round 78, we find that 5.25 pounds of brown cake powder of density 1.80 to 1.83 gave an observed velocity of only 1435 feet to a projectile weighing 12.25 pounds, the cakes being 1.5 inch thick. Thus the efficiency of the brown powder was only 32.8 foot-tons per pound of powder. (This charge consisted of 7 brown and 1 black cake. If the black cake is credited with the same efficiency as that used in round 79, then the actual efficiency of the brown powder will be found to be only 28.1 foot-tons per pound.) Round 79 was fired immediately after round 78. In this round No. 79, 5 pounds of very light density powder were fired with 12-pound projectile, the cakes being 1.5 inch thick, as in round 79. The observed velocity was 1845 feet, giving an efficiency of 56.6 tons per pound of powder. (See page 422 respecting reduction of efficiency due to increased air-spacing.) The air-spacing and the other conditions being in all respects exactly the same as in round 78, we find that the black powder was 72 per cent more effective than the brown powder.

Now the larger and the longer the gun is, the greater the weight and resistance of the projectile, the more dense may be the powder cakes, providing the material will burn with sufficient rapidity to be converted into gas before the projectile has accomplished more than 43 per cent of its travel in the gun, because the projectile is a longer time traveling up the bore of the gun, provided the mean gas-pressure be the same. If the projectile be of the same proportional length, and the gun be also of the same proportionate length, and the muzzle velocity be the same, say 2000 feet in every case, then the time of travel up the bore will be directly in proportion to the length of the guns. Thus:

TABLE II.

Diameter of gun. Inches.	Travel of projectile. Feet.	Length of shot. Inches.	Muzzle velocity. Foot-sec.	Time of travel. Sec.
3.0	7.0	10.0	2000	0.003
6.0	14.0	20.0	2000	0.006
12.0	28.0	40.0	2000	0.012

(This table is calculated on the assumption that the powder charges are of such quality as to give the same maximum pressure in all these guns. But if the same description of powder be used in all these guns, the maximum pressure will vary with the caliber.)

From which we deduce that the whole of the powder should be consumed by the time the projectile has completed .43 of its entire travel. Consequently the powder must be of such density and of such maximum thickness that it shall be consumed (under the pressure existing in the chamber and bore of the gun) at such a rate that the time of combustion shall equal the time taken by the projectile to complete .43 of its entire travel. But the time taken by the projectile to complete this distance will depend not only on the pressure of the gas, but also on the weight of the projectile and on the amount of the resistance of the rotating ring in passing into the rifled portion of the gun.

From an examination of the results of the experiments of Sébert and Hugonist and many more recent experiments, it would appear that the velocity of combustion of powder of very high density, when fired behind projectiles with normal rotating rings, must be much more rapid than that suggested by Piobert's assumed law and given by calculation in Table I. And from some other investigations which have been made (not given in the paper), it appears that the time of complete combustion of the charge of a 6-inch gun should not exceed 0.0062 second if the projectile weighs 100 pounds; and to obtain an absolutely uniform pressure during combustion, the weight of powder converted into gas should be proportional to the velocity of the projectile during the combustion of the whole charge. Therefore, if the velocity of combustion of the powder be constant under uniform pressure, the area of the combustion surface should increase in proportion to the increase of the velocity of the projectile during the combustion of the charge.

Now, it has been seen from Table I, in this paper, that the Quick cake powder is consumed in a much shorter time than the other powders, hence a very much higher density may be used and the whole charge properly consumed before the projectile completes more than .43 of its total travel. And this will give a low pressure, because the combustion and gas-generating surface is *not* at a maximum when the projectile is at rest and offering great resistance by its rotating ring, as it is in the case of P or prism powder. With a P powder of a high density and large size, the time of combustion would

be so great that the grains would probably be blown out of the gun unburnt. See Noble and Abel's Researches, page 131.

It is dangerous to use P powder of low density and large size, because it is found to produce abnormally high pressures, due probably to the large prisms being split up by the hot gases penetrating into them and converting them into small grains, and therefore producing extremely rapid combustion.

Again, it is equally dangerous to use P powder of high density and small size, because the initial ignition surface is so very large. For in a charge of say 100 pounds of powder composed of 2-inch cubes, the initial ignition surface would be roughly 4800 square inches, falling to zero as the combustion terminated, the reduction of surface being illustrated by Fig. 4, where, as also in Figs. 5 and 6, AO represents the area of initial ignition surface, OX the time of combustion, and the point X the area of the terminal combustion surface.

If the 100-pound charge be composed of 1-inch cubes, the initial ignition surface will be 9600 square inches, and the time of combustion at atmospheric pressure will be only 0.5 second, the reduction of the surface by combustion being illustrated by Fig. 5.

And if the 100-pound charge be composed of ½-inch cubes, the initial ignition surface will be increased to 19,200 square inches, and the time of combustion reduced under atmospheric pressure to 0.25 second. The process of combustion will be illustrated by Fig. 6.

With the cake powder there is complete control over the time of combustion of the whole mass (however high the density may be) by making the perforations more or less numerous, and thus varying the thickness of the powder burnt. Now the higher the density of the powder the more energy is stored up in a given volume, hence it is preferable to have the propelling material of high density so that it shall burn steadily and consequently generate the gas uniformly, the perforations being sufficiently numerous and close together to permit the whole mass to be converted into gas in the time required to obtain the maximum result in any gun of given lengtl.. The higher the density of the cake powder the less liability is there also for the cakes to be broken up into small fragments. Any such rupture of the cakes would of course affect the results. But as the whole of the cakes are ignited simultaneously, so every cake would be enveloped in its own atmosphere of fire, of uniform density and pressure, which would tend to protect every element or cake in the charge from being crushed up or ignited by impact with the other

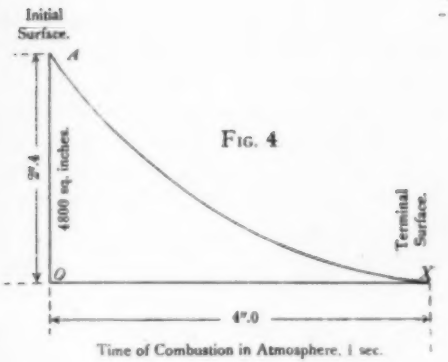


FIG. 4

Time of Combustion in Atmosphere, 1 sec.

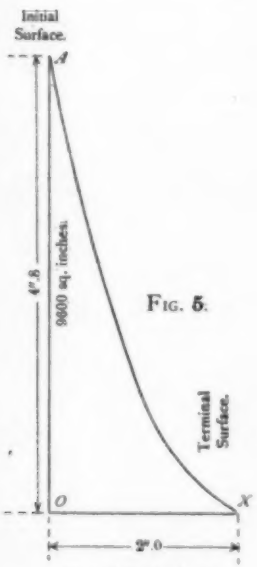


FIG. 5.

Time of Combustion in Atmosphere, 0.5 sec.

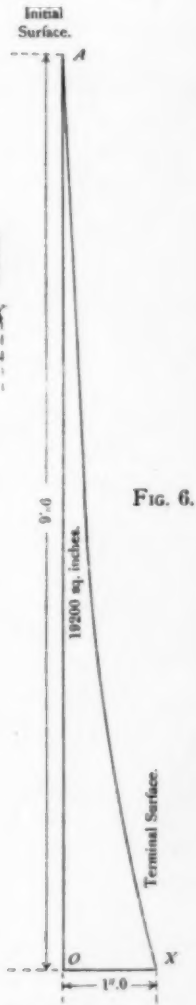


FIG. 6.

Time of Combustion in Atmosphere, 0.25 sec.

To face page 426.

elements or cakes, for every cake would be equally and uniformly repelled by the others.

Hence we see the necessity for every gun of any given length to be supplied with powder suitable to its length and to the time the projectile is traveling up the bore.

Thus we may obtain a very high efficiency per pound of powder, and in consequence of the air-spacing being properly arranged, we obtain simultaneous ignition of the whole charge. Again, the initial ignition surface being reduced to a minimum, we obtain a low initial pressure, which enables us to reduce the total amount of air-spacing in the chamber of the gun to a minimum. Then by reason of the charge being composed of a dense powder, with small air-spacing, the charge will occupy but a comparatively small space in the gun, from which an economy will arise, as it permits of the gas-pressure acting for a greater space and longer time on the base of the projectile. And most important of all, for naval service, is the fact that the smaller the size of the charge the greater is the number of charges that can be carried in the magazine. We thus approach the ideal but impossible propelling agent previously referred to.

There are some practical advantages in the use of the Quick cake powder when cemented, waterproofed, and made up into cartridges, which may be referred to.

It is well known that the hexagon or prism powder and the pebble powder cannot be made up into perfectly rigid cartridges for large guns, so as to fit the chamber with even a moderate amount of accuracy. The charges of the prism or pebble powder, instead of being cylindrical, are polygonal, having sharp angles, as shown in the annexed diagram, which is taken from the "Handbook of Artillery Material," by Captain Morgan, R. A. (Plate VIII, page 37).

And it can be seen from the Ordnance Reports, page 21, Part 1, ending March, 1887, that these "service" cartridges became unserviceable. It was reported from Gibraltar that on examining the charges, the Inspector of Warlike Stores "found the powder to be very dusty, and an amount of dust had worked through the bag." Some "prisms were much broken." "The cartridge was unserviceable." Suggestions have been made for the use of a stronger material for the bags. The authorities on board the Excellent, gunnery ship, considered that "as all heavy B. L. guns will be thoroughly washed out before reloading, strengthening the bags by stays of flannel or even leather would be admissible."

It is very evident that in the transport and handling of ordinary cartridges containing grain pebble or prism powders, a considerable amount of dust must be generated by the attrition of the powder, and that the cartridge must become strained over the sharp edges or corners of the powder, so that the powder dust will work through the bags. It is thus easy to see that the smallest particle of fire in the gun will ignite this dust on the charge being inserted, the flash from which will ignite the whole charge.

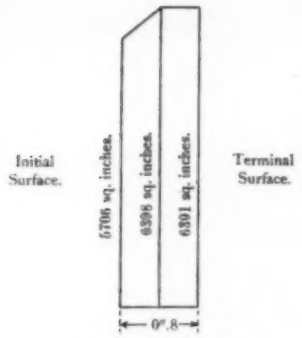
Even in the case of perfectly new cartridges, it is highly probable that the cartridge bag is not unfrequently cut or torn on these sharp edges, on the charge being forced into the chamber, so that the powder may be uncovered in places, and thus rendered liable to be ignited by fire or friction against the hot metal or residuum in the chamber. It is probable that this is frequently the cause of the mysterious premature explosions which occur on reloading guns.

With the Quick cake powder the cartridges will be truly cylindrical, so that there can be no cutting or straining of the cartridge cases. The cakes being locked together by the clutch-like surface, there can be no attrition of the surfaces to generate dust, even if the cakes be not cemented together. At a very trifling expense, however, the whole of the cakes forming a charge or section of a charge may be cemented into one rigid mass, and the whole rendered waterproof and airtight. The front end of the cartridge may be protected by a shield or wad of non-inflammable material, so that any small amount of burning residuum would be swept forward by it out of the way of the powder, and thus premature explosion, even if fire remained in the gun, would be prevented. It is perhaps needless to say that the cylindrical form of the cartridge would greatly facilitate storage, handling and loading.

It may be reasonably believed that whatever development the nitro materials may have in the future, that their ballistic efficiency, keeping qualities, and their facility in use when made up into cartridges, will be much increased by being formed into cylindrical cakes with the central air-spacing, the whole charge being cemented together and made waterproof on the system herein described.

Fig. 7 shows combustion surface of 100-lb. charge of perforated cake powder, 6".7 dia., 1".7 thick, and having 60 perforations.

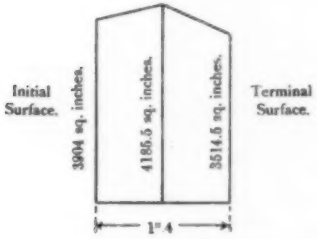
FIG. 7.



Time of Combustion in Atmosphere, 0.2 sec.

Fig. 8 shows combustion surface of 100-lb. charge of perforated cake powder, 7".7 dia., 1".75 thick, and having 40 perforations.

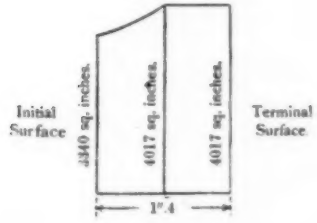
FIG. 8.



Time of Combustion in Atmosphere, 0.35 sec.

Fig. 9 shows combustion surface of 100-lb. charge of perforated cake powder, 7".7 dia., 2".5 thick, and having 40 perforations.

FIG. 9.



Time of Combustion in Atmosphere, 0.35 sec.

To face page 428.

Fig. 10 shows the influence of the thickness of the cake on the progress of combustion.

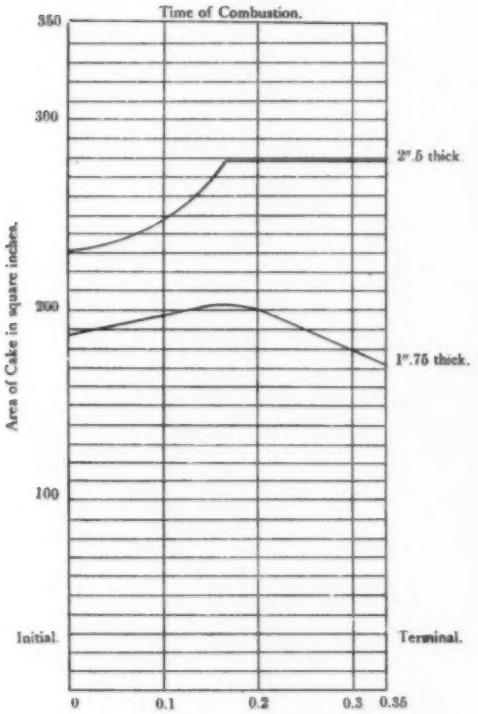


FIG. 10.

Diagram showing combustion of perforated cakes 7".7 dia., having 1 central perforation 0".6 dia., and 40 concentric perforations 0".25 dia.; one cake being 1".75 thick and the other 2".5 thick.

To face page 428.

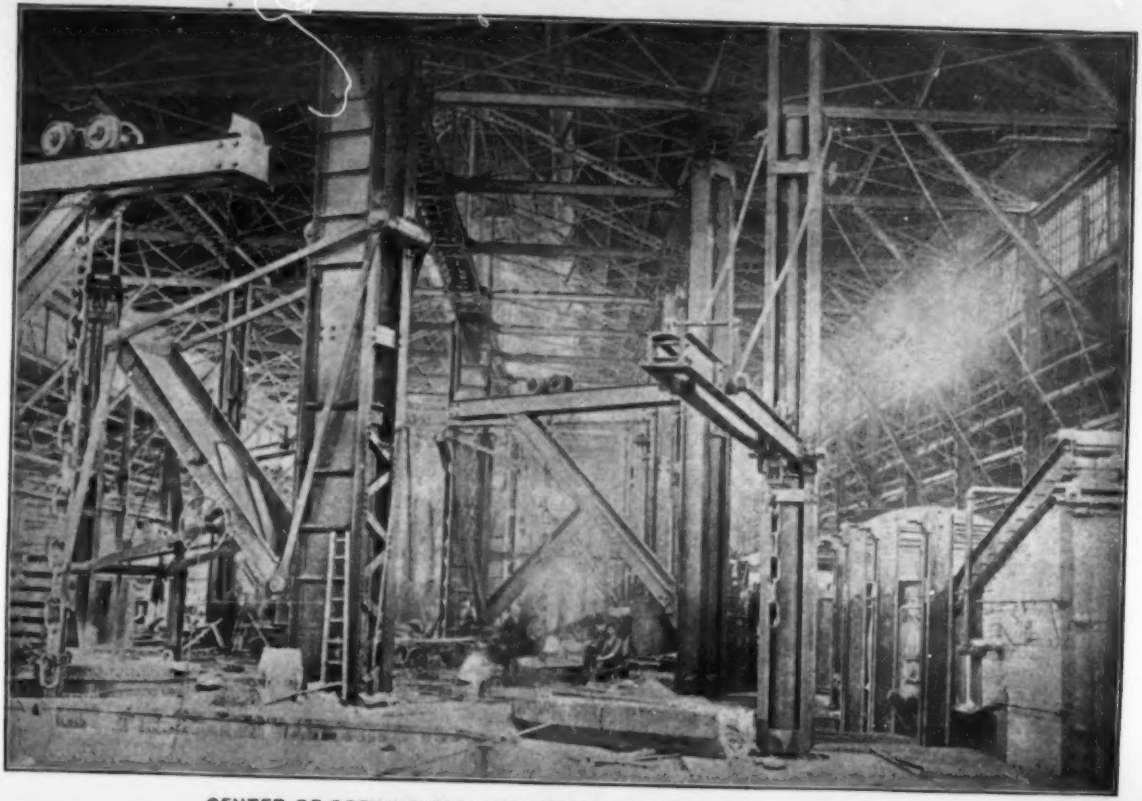
QUICK'S BREECH-LOADING GUN, EXPERIMENTAL 3-INCH.

SELECTIONS FROM EXPERIMENTAL ROUNDS WITH THE QUICK CAKE POWDER.

Date of Trial.	No. of Round.	Description of Powder.	Weight of Charge.	Weight and Description of Projectile.	Velocity Observed.	Recoil.	Pressure at Rear of the Chamber.	Pressure at Base of the Projectile.	Remarks.
			Lbs.	Lbs.	Foot-secs.	Ft. Ins.	Tons per sq. in.	Tons per sq. in.	
4/5/87	16	Quick's Cake. Experimental No. 3.	6.5	12.5	2081	12 3	....	....	Old wood platform. Inclination of slide 1 in 12.
"	17	" " "	6.5	12.5	2080	12 3⅛	....	....	
"	18	" " "	6.5	12.5	2094	12 3	....	....	
"	20	" " "	6.5	12.25	2107	12 0	....	....	
"	21	" " "	6.5	12.25	2136	12 0	....	....	
18/6/87	27	" " No. 1.	6.5	12.0	2050	9 10	....	Did not exceed 14 tons.	Inclination of slide altered to 1 in 6.
"	28	" " No. 2.	5.625	12.0	2000	9 3	....	....	
"	29	" " No. 3.	5.5	12.0	2145	8 11	....	14.05	
"	30	Quick's Cake. Mixture of Experimental Nos. 2 and 3.	6.125	12.25	2130	10 6	....	Shot lost.	
15/11/87	34	Quick's Cake. Experimental No. 3. This powder had been exposed to the atmosphere of the temporary magazine for 5 months.	8.25	12.14	....	12 8	....	13.8	Powder chamber enlarged by lengthening from 14.5 to 18.125 ins., and volume increased from 145 cubic inches to 180 cubic inches.
14/3/88	38	Quick's Cake. Experimental No. 4. *Special rapid-burning powder.* Cemented.	4.0	12.25	...	1 3	Did not exceed 13 tons.	Not taken.	New Anderson Recoil Carriage used.
21/3/88	40	Quick's Cake. Experimental No. 5. *Special rapid-burning powder.* Cemented.	6.0	12.0	1917	.. 8	14.98 Mean.	....	New Anderson Recoil Carriage, readjusted.
"	41	Quick's Cake. Experimental No. 4. *Rapid-burning powder.* Cemented.	6.0	12.0	2011	.. 8	16.8 Mean.	....	
"	42	Quick's Cake. Experimental No. 3. Not protected.	6.0	12.0	1855	.. 7⅞	14.75	....	Anderson's Recoil Carriage.
"	43	Quick's Cake. Experimental No. 4. *Rapid-burning powder.* Cemented and water-proofed.	4.0	12.0	1704	.. 7⅞	....	....	This cartridge was placed in water for four minutes, and was wet for ten minutes before firing. It occupied only one-half of the length of the chamber, the rear half being empty.
23/3/88	50	Quick's Cake. Experimental No. 6. Medium-burning powder. Not cemented.	6.0	12.0	2050	.. 9⅛	....	....	Anderson's Recoil Carriage, re-adjusted.
"	51	Quick's Cake. Experimental No. 4. *Rapid-burning powder.* Cemented and water-proofed.	4.0	12.0	1654	.. 9	....	....	This cartridge was soaked in water for 45 minutes. The first primer failed to ignite the charge, second primer fired it. This cartridge did not half fill the chamber, a length of 8 ins. being left from the rear end of the cartridge to the face of the breech-screw.

Selections from Experimental Rounds with the Quick Cake Powder.

Date of Trial.	No. of Round.	Description of Powder.	Weight of Charge.	Weight and Description of Projectile.	Velocity Observed.	Recoil.	Pressure at Rear of the Chamber.	Pressure at Base of the Projectile.	Remarks.
			Lbs.	Lbs.	Foot-secs.	Ft. Ins.	Tons per sq. in.	Tons per sq. in.	
23/3/88	52	Quick's Cake. Experimental No. 7. Mixture or combination of various densities.	6.75	12.0	2064	.. 9¾	....	....	
"	53	Quick's Cake. Experimental No. 8. Mixture of slow and rapid-burning powders.	6.75	12.0	2100	.. 9¾	....	....	
"	54	Quick's Cake. Experimental No. 9. Mixture of slow and rapid-burning powders. Not cemented.	6.625	12.0	2050	.. 9¾	....	....	
"	57	Quick's Cake. Experimental No. 6.	8.0	12.0	2250	.. 9¾	Not taken.	....	Anderson's Recoil Carriage.
27/3/88	59	Quick's Cake. Experimental Nos. 2 and 3 mixed.	5.56	12.0	Not taken.	.. 11¾	Did not exceed 13.78 tons.	....	Anderson's Recoil Carriage, again readjusted.
"	60	Quick's Cake. Experimental No. 4.	6.0	12.0	"	.. 11¾	15.37	....	
"	61	" " No. 3.	6.5	15.0	"	.. 11¾	Did not exceed 13.78 tons.	....	
"	62	" " No. 4.	7.0	12.0	"	.. 11¾	17.9	....	
10/5/88	73	" " No. 6. Cemented and water-proofed.	6.0	12.0	"	.. 11¾	....	....	No difficulty in ignition, although cartridge was soaked in a bucket of water for 33¾ minutes.
18/5/88	75	Quick's Cake. Experimental No. 10. Black powder. Not cemented. *Special rapid-burning powder.*	5.0	12.25	"	1 ..	17.5	....	
"	76	Quick's Cake. Experimental No. 6. Black powder. Water-proofed.	5.0	12.25	"	.. 11¾	13.8	....	This cartridge was soaked in a bucket of water for 1 hour 50 minutes.
" (See for comparison Rounds 27, 29, 57, 59 and 61.)	77	Quick's Cake. Experimental No. 10. Black powder. Not cemented. *Special rapid-burning powder.*	6.875	12.25	2118	1 0¾	23.2	....	This round was fired with the view of severely testing the strength of the breech-mechanism. There was not the slightest sign of weakness, of jamming of the breech, of the firing mechanism, nor of the extracting gear for the vent-sealing firing-tube. The breech was opened with two fingers only. There was no escape of gas.
"	78	Quick's Cake. Experimental No. 11. Brown powder. Not cemented.	5.25	12.25	1435	.. 11¾	Did not exceed 13 tons.	....	Much residuum, of a salt-like appearance, principally up the bore of the gun.
"	79	Quick's Cake. Experimental No. 10. Black powder. Not cemented. *Special rapid-burning powder.*	5.0	12.0	1845	1 0¾	16.8	....	



CENTER OF OPEN-HEARTH DEPARTMENT, HOMESTEAD STEEL WORKS,
Showing Casting Pits, Hydraulic Cranes, etc.

To face page 431.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE HOMESTEAD STEEL WORKS.

By W. Richards and J. A. Potter.

The Homestead Steel Works of Carnegie, Phipps & Co., Limited, are situated on the south bank of the Monongahela river, some nine miles above Pittsburgh, and on the immediate line of the Pittsburgh, Virginia and Charleston R. R., and the Pittsburgh, McKeesport and Youghiogheny R. R., the former being one of the Pennsylvania R. R. systems, and the latter one of the Vanderbilt R. R. systems. These two roads, with the river itself, afford exceptionally good opportunities for the transportation of the finished products of the works to the markets. The property of the company comprises some 89 acres, of which the works proper occupy 42 acres of level ground, having a frontage of 3104 feet on the river. On the slope back of the works are the general offices, stables, the company's hotel (built and run for the benefit of the employes of the works), the residences of the various superintendents of departments, and further back on the slope the houses of many of the married men employed in the mills.

The plant originally consisted of a converting mill with two 5-ton vessels, a blooming mill, and a 23-inch rail mill, and was owned and operated by the Pittsburgh Bessemer Steel Co. Under the management of this company the first heat was blown in the converters on March 19, 1881.

Carnegie, Phipps & Co., Limited, purchased the plant, and three years thereafter the rolling of rails was discontinued and the rail mill converted into a mill for rolling structural shapes, such as small I beams, channels, eye-bars, angles, and billets. In the meantime the 33-inch mill for rolling large sections of beams had been erected.

The 33-inch and 23-inch mills, housed in the same building, are at the extreme western side of the property, and have low grade standard gauge tracks on either side, for shipping purposes, in addition to a trestle-work at the east side, originally intended to bring fuel to the boilers (an arrangement which has been rendered unnecessary by the adoption of natural gas as a fuel throughout the entire works). In this connection it might be well to remark that although natural gas is the general fuel, all the furnaces, boilers, etc., throughout the entire plant, including those of the newer mills, of which we speak later on, are so arranged that in the event of the failure of, or a marked diminution in, the supply of natural gas, a return could be made with the least possible expenditure and delay to the old system of producers and the use of coal or coke at the boilers.

Such, however, are the advantages arising from the use of natural gas as a fuel, that in the event of any such contingency as the failure of the supply, large companies would doubtless erect works for the production of gas and pipe it through the old lines; or various works would put up water-gas plants of their own and continue to operate their furnaces and boilers as under the present system.

East of the 33-inch and 23-inch mills are the engine and boiler houses of the converting and blooming mills, and east of them are the mills themselves. The converting mill is completely surrounded by a trestle-work, on which the cars run to discharge in bins below the various grades of pig iron, scrap, etc., that are used as a charge in the vessels, after being melted down in the cupolas.

In the year 1887 the company added to the plant an open-hearth department, originally of four furnaces, and since increased to seven furnaces and a plate mill, and during the following year an armor plate mill was added.

The plate mill and open-hearth building lies east of the converting mill, and the armor mill is just beyond. A 10-inch mill, built in 1888, occupies a place near the 23-inch mill.

All these mills are set somewhat back from the river, and the ground close to the water front is occupied by a beam yard, certain of the shops, water works, and the laboratory.

CONVERTING DEPARTMENT.

The converting mill building is of brick, with an iron roof, and is 119 feet 8 inches long by 73 feet wide. The iron is melted in four cupolas, 24 feet high and 8 feet in diameter, and the spiegel in two cupolas,

24 feet high by 6 feet in diameter. Metal is brought to these cupolas by two hydraulic hoists. The molten iron from the cupolas is carried by means of iron runners lined with refractory clay, into ladles of 5 tons capacity, which are then transferred by means of an 8-ton hydraulic crane.

The vessels (or converters) are two in number, and stand opposite each other at either side of the building, with their noses pointed outward. Their capacity is five tons, but as high as seven tons have been made at a single heat. The steel from the converters is poured into a five-ton ladle, held by an eight-ton hydraulic crane, by which it is swung to a semi-circular pit of 20 feet diameter, where it is poured into moulds. Three five-ton cranes transfer the ingots to cast-iron cars or buggies, which carry them to the other mills. Two five-ton hydraulic cranes are also employed to assist in changing the converter bottoms. The ladles are lined in a lean-to adjoining the converting mill, in which is also located a small reverbatory furnace for heating ferro-manganese. Bottoms for vessels are renewed in a special building, where are located two ovens for drying them. The capacity of this mill is 14,000 tons of special low carbon steel ingots per month.

Engine House.—The engine house is of brick, with an iron roof, and is 136 feet long by 38 feet 6 inches wide. Here are located two Mackintosh, Hemphill & Co.'s blowing engines, having a 31-inch steam cylinder, 46-inch air cylinder by 36-inch stroke; one Southwark Foundry & Machine Co.'s blowing engine, with 56-inch steam cylinder, 80-inch air cylinder, and 48-inch stroke, which supplies blast to the converters at a pressure of 20 pounds per square inch; also an 18 × 24 horizontal engine operating four No. 7 Baker blowers, which supply blast at a pressure of one pound per square inch to the cupolas. In a wing of the engine house are located three Worthington duplex steam pumps and two Epping & Carpenter pumps, supplying a hydraulic pressure of 500 pounds per square inch for the converting and blooming mills.

Boiler House.—The boiler house is 300 by 51 feet, and is also of brick, with an iron roof. In it are located twenty boilers, in five sets of four each; each being 44 inches diameter and 24 feet long, fed by two pumps. These keep up a steam supply for converting and blooming mills of 115 pounds per square inch.

Mixing House.—The mixing is done in a brick building, 135 feet by 50 feet, by one Blake crusher, one Gates crusher, and two pug

mills made by William Tod & Co., which are all operated by one 12-inch × 12-inch Gardner engine.

BLOOMING MILL.

This mill connects with the converting mill, and is of brick, with an iron roof, 178 feet 6 inches × 73 feet. Ingots from the converting mill are delivered in buggies, in an upright position, and are transferred by hydraulic cranes to the soaking pits. There are three sets of these pits, and three pits to a set; one crane doing the work for each set. The reheated ingots are placed by a crane on tables which carry them to the mill proper. The rolling is done by a 28-inch reverse train driven by a pair of Mackintosh, Hemphill & Co.'s engines, 28-inch cylinder, 48-inch stroke, and running fifty revolutions per minute. After the steel has been reduced to the required size, it is delivered by tables to a vertical shearer and driven by an 18-inch × 24-inch engine, and capable of shearing 100 square inches. Here the steel is sheared to the desired length, and is then loaded on cars by means of a small hydraulic crane and distributed to other mills, or carried away for shipment. In connection with this mill there is a 7000-pound hammer, built by Mackintosh, Hemphill & Co., and which is used for special slabs and blooms. Heating for the hammer is done by a reverberatory furnace (Siemens type). Two five-ton cranes handle the material at hammer. The product of this mill is blooms, billets, and nail plate, and its capacity is 7800 tons per month.

The product of this mill is brought out in buggies and unloaded by means of hand cranes, when every piece is carefully inspected, and the piece is loaded on the cars and shipped away, or, if it is intended to be treated in the works, it is sent to the 23-inch or 10-inch mill to be rolled into shapes.

THE 23-INCH MILL AND 33-INCH MILL.

These two structural mills, which are employed to roll angles, eye-bar flats, channels, and all I beams from 4 inches to 24 inches, are located in the same building, which is 602 feet long and 84 feet wide, and has three wings on one side and a lean-to on the other. All three wings are 80 feet in depth, the central one being 120 feet wide and the others each 68 feet.

This building, like those of the converting and blooming mills, is of brick, with iron roof, and these three buildings together form the original plant of the Pittsburgh Bessemer Steel Co.

23-inch Mill.—This mill was, as we have previously stated, formerly used for the production of rails, but has been remodeled, and now rolls angles from 2 inches × 2 inches up to 6 inches × 6 inches; eye-bar flats from 8 inches × 2 inches down to 3 inches × ⅝ inch; channels from 4 inches to 15 inches; I-beams from 4 inches to 8 inches; and billets from 2 inches square to 3½ inches square. It occupies the southern end of the above described building, facing southwards, and discharges its product through the south end of the mill, on extensive beds, where it is loaded on cars and shipped.

Blooms from the blooming mill are brought in buggies through the 68-foot wing, and charged into reverberatory reheating furnaces 15 feet × 17 feet, of which there are three. The roll train is three high and consists of three stands of rolls, roughing and finishing. The three stands are in a continuous line at right angles to the main axis of the building, and are run by one 42-inch × 48-inch Mackintosh, Hemphill & Co.'s engine. Tables carry the finished product of the mill from the last pass to a hot saw which removes the crop ends. Two hydraulic cranes are used for roll changing in this mill. At the lower end of the mill the finished shape is cooled on hot beds and finished as desired. For this purpose one crocodile shear with engine attached, two vertical angle shears, one horizontal straightening press, one friction saw running 2000 revolutions per minute for cold sawing, and one angle straightening machine are located in this part of the building. The monthly product of this mill amounts to 2500 tons, approximately.

33-inch Mill.—This mill, which is located at the north end of the 600-foot building, is employed to roll 9, 10, 12, 15, 20, and 24-inch I beams. Ingots from the converting mill are brought in buggies and charged in gas heating pits (six in number), whence, after heating, they are taken to the roughing rolls. The roll train is three high and consists of three stands of rolls, one for roughing and two for finishing, standing in a continuous line across the mill, and run by a 46-inch × 60-inch Mackintosh, Hemphill & Co.'s engine traveling 55 revolutions per minute.

The heated ingot is "cogged down" on the roughing train to what is known as a "shape," and is then carried by roller tables to an inverted shear operated by the ascent of the bottom knife, where it is sheared into lengths and afterwards conveyed in buggies back to the northern end of the mill, where reheating is effected in three reverberatory furnaces situated near the heating pits. The reheated

shape is wheeled on an iron buggy to the finishing rolls where the beam is finished; carried thence by a table to a hot saw, which saws off the crop ends, and the finished beams are then drawn off sideways on long hot beds, where they are permitted to cool before being further handled. Ingots at the pits are handled by two 7-ton and two 4-ton hydraulic cranes. Ingots are drawn and placed on tables at roughing rolls by one Yale & Towne 5-ton locomotive crane, and roll changing is effected by two steam cranes. The capacity of this mill is about 3300 tons of finished beams per month.

Boilers and Pumps.—In the 120-foot wing of the main building are located the boilers which supply steam to the two mills. These are 24 in number, in six sets of four each, 44 inches diameter and 24 feet long, with three stacks 100 feet high. A steam pressure of 115 pounds is maintained. Here also are two Worthington duplex pressure pumps supplying the water pressure for the mills.

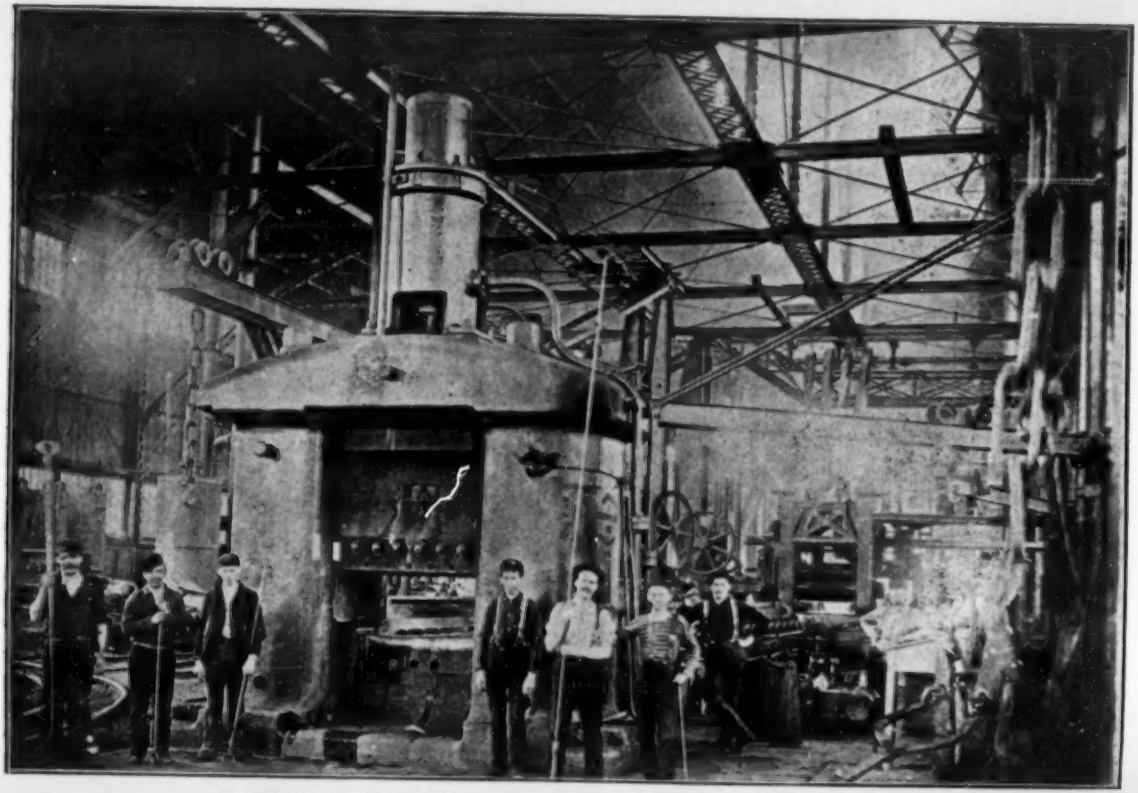
Store Room and Electric Light Plant.—In this wing also the store rooms are placed, as well as two 60-light dynamos for supplying the electric lights throughout the yards and mills.

Beam Finishing Department.—Here the beams are taken from the hot bed to machines located in the lean-to spoken of, and straightened, coped, punched, drilled, or otherwise fitted as may be required. In order to finish the beams ready for commercial purposes, they are first sawed to the exact length by friction saws running at a speed of 2000 revolutions per minute. Four of these are situated about the yard, and each of them is run by a separate engine to do this work. For the purpose of coping, straightening, etc., the beam finishing department is further equipped with one slotting machine, one rotary milling machine, two 30-inch drill presses, one vertical coping machine, two vertical punching machines, two horizontal straightening presses for 6-inch to 20-inch beams, and one large horizontal straightening press for 24-inch beams.

10-INCH MILL.

This mill adjoins the 23-inch structural mill, and rolls small rounds, flats, and structural shapes.

The building is of iron and steel throughout, and is 180 feet long and 43 feet wide. The steel is heated in reverberatory furnaces of the Siemens type. These are located in the 68-foot wing of the 23-inch mill building, and the heated steel is carried thence by an overhead trolley to the rolls.



HYDRAULIC SHEARS, SLABBING MILL, HOMESTEAD STEEL WORKS.

To face page 437.

The rolls are in four stands, three high, and are driven by a Porter Allen 16 × 30 engine, running 180 revolutions per minute. The finished steel is delivered on hot straightening beds; cooled and sheared by a vertical shear driven by an engine attached.

Steam supply is obtained from the 33-inch and 23-inch mill boilers.

The product of this mill amounts to about 400 tons per month, running on day turn alone.

OPEN-HEARTH DEPARTMENT.

The open-hearth furnaces and the plate train and finishing machinery are housed in the same building. This is 967 feet long, and is built entirely of iron and steel. The main building, containing open-hearth plant and the plate mill proper, is 501 feet long and 86 feet in the main span, with a 45-foot lean-to on each side. The inspecting and marking-out department is 273 feet × 43 feet, and the shearing department is 187 feet × 86.

The open-hearth furnaces are seven in number.

The furnaces all use natural gas as a fuel, the stacks being placed at the back, and checker-work in the flues preheating the air.

Charging is done from the general floor level. These furnaces are arranged in pairs, with casting pits between each pair. Nos. 2, 3 and 4 are opposite Nos. 7, 6 and 5 respectively.

Between the pairs of furnaces are the hydraulic ladle cranes, which are directly on the center line of the building, and on either side of the cranes are semi-circular pits, capable of taking four sets of moulds. Each pair of furnaces are attended at the pits by two seven-ton and two twenty-ton hydraulic cranes, which command the furnace itself, the casting and ladle pits, and the narrow-gauge tracks over which the ingot moulds are removed and the product of the furnace is carried to the mill.

At one end of the open-hearth department is a small steel foundry, with core room, etc., where special steel castings for use at the works are made.

The capacity of the open-hearth plant amounts to 10,000 tons of ingots per month.

THE SLABBING MILL.

The slabbing mill building is of steel and iron, 300 feet long and 120 feet wide, with a 35-foot lean-to for boilers.

Eight heating furnaces; vertical pits six feet in diameter and seven

feet deep, with circular covers, are arranged in pairs in the northern end of the building. Two 35-ton hydraulic cranes, swung by rack and pinion, and fitted with a simple hydraulic tackle for gripping ingots, charge and draw these furnaces.

The slabbing train itself is a universal mill. The vertical rolls are of steel 20 inches in diameter, and are driven fifty revolutions per minute, by a pair of E. P. Allis 30-inch × 54-inch reversing engines running 100 revolutions per minute. And the horizontal rolls are 32 inches in diameter, and are driven by a pair of E. P. Allis 40 × 54 reversing engines. This train has already dealt with 48-inch × 48-inch ingots weighing 38,000 pounds, and is capable of taking a 25-ton ingot 48-inch × 54-inch and rolling to a section 11-inch × 3-inch.

Tables carry the ingot from the roll train to the shear. Tables on both sides of the rolls are run by a pair of upright 10 × 12 Crane reversing engines, and the shear table by a pair of horizontal 8 × 10 Crane reversing engines.

The shear power is hydraulic and operates by the descent of the upper knife, with a pressure of 4000 pounds per square inch (given by two Southwark Foundry pressure-pumps, 65-inch steam cylinder, 10-inch water cylinder, and 8-foot stroke); the shear develops somewhat over 3000 tons power, and is capable of shearing a 48-inch × 24-inch section. A general pressure throughout the mill of 500 pounds per square inch is supplied by two Wilson & Snyder's duplex pumps.

In the lean-to are six batteries of four each, of boilers 44½ inches diameter and 26 feet 6 inches long, supplying the steam pressure of 120 pounds.

Besides the two cranes for handling ingots at the pits, there are in the mill two 16-ton and seven 5-ton slab cranes.

Aside from the ponderous machinery of the roll train, and the great power and simplicity of design of the hydraulic shear, what is particularly striking about the mill are its admirable arrangement and shipping facilities, and the very small number of men required to run it. All slabs from this mill before being shipped away or sent to the plate mill are subjected to a thorough inspection. Capacity, 10,000 tons per month.

THE PLATE MILL.

Ingots were formerly roughed and finished in this mill, but are now roughed in the universal mill, to slabs, which are brought by small

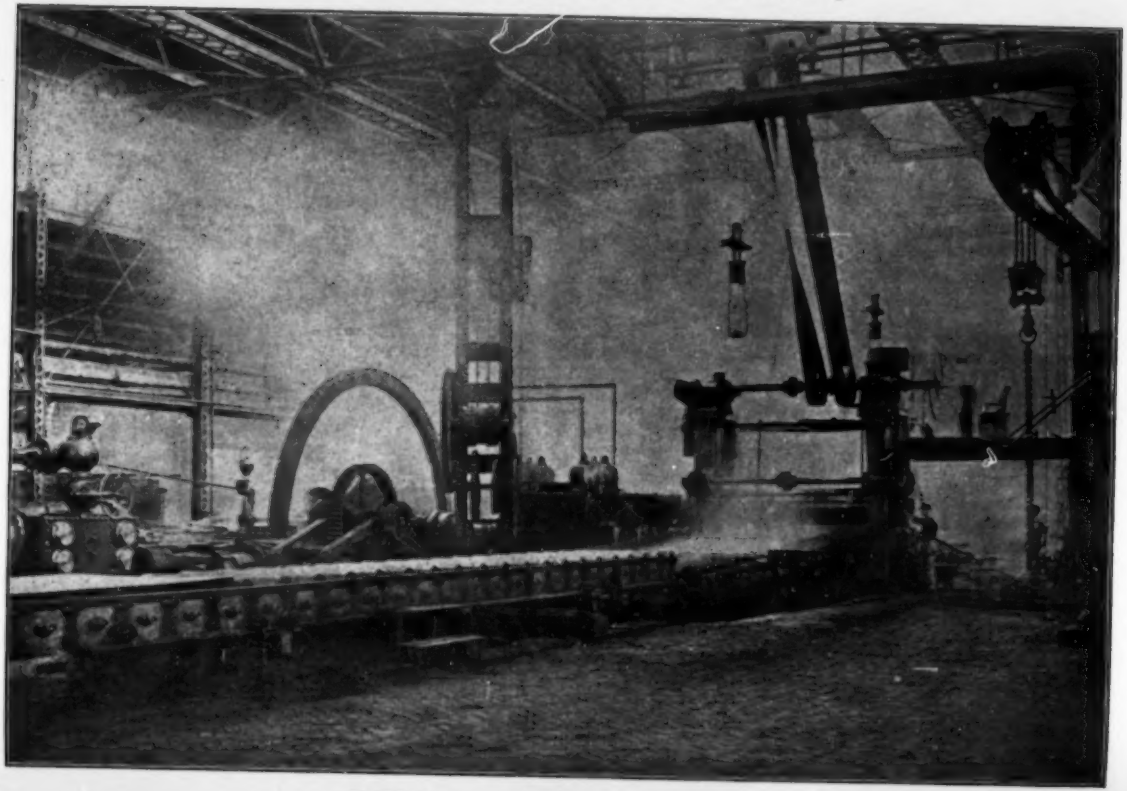


PLATE MILL, HOMESTEAD STEEL WORKS.
Rolls 119 inches.

To face page 439.

cars directly to the furnaces of the plate mill. Three heating furnaces, 25 feet by 6 feet 9 inches, are located on each side of the mill, charging and drawing being done by special hydraulic cranes, controlled by one man who is carried about on a seat suspended from the jib.

Reheated slabs are placed by these cranes on tables of live rollers which carry them to the mill. The mill is three high, the top and bottom roll being 119 inches long and 32 inches in diameter, and the middle roll 119 inches long and 22 inches in diameter, making 50 revolutions per minute. A 42 by 54 horizontal Mackintosh, Hemphill & Co. engine drives the roll train, and screwing down is done by the means of a small vertical engine, friction clutches and worm gearing.

From the rolls the finished plate comes slowly down a roller table 363 feet long and 5 feet 1¾ inches wide, driven by a line shaft and bevel gearing. An overhead traveling crane runs the full length of the table, so that the plate can be removed at any point, turned over for inspector on the lower side, or shifted to any part of the table or floor as may be desired. On this the plates are allowed to cool, air having free access below the rollers, and are inspected above and below, and stamped as to quality, dimensions, etc., and carefully laid out for shearing. The inspector examines stamping and marks and stamps test pieces. From the table, plates are rolled on casters to the shear. The casters are small rolls, supported on vertical shafts which are held in holes in the floor.

The shearing is done by three shears, each with a knife 135 inches long, and two with 36-inch knives, all built by Morgan Engineering Company.

The shipping department is supplied with sixteen cranes, which place the plates directly on cars on switches of the Pennsylvania R. R. system.

Steam power at 100 pounds pressure is applied by four batteries of four boilers each. Each boiler is 44 feet in diameter by 24 feet 4 inches long, with two 16-inch flues; draught being provided by two wrought-iron stacks 125 feet high. Two duplex Southwark Foundry pumps feed the boilers, and two Southwark Foundry and one Wilson, Snyder & Co. pressure pump with an 18-inch accumulator supply the hydraulic pressure of 500 pounds per square inch. This mill has rolled plates from 3 inches thick, 115 inches wide, down to $\frac{3}{32}$ inch thick and 117 inches wide, any length, and can handle plates as high as six tons in weight.

Capacity, 5000 net tons per month.

In connection with the plate mill is a special set of rolls for bending plates and beams, capable of bending the largest plates that can be rolled in the mill.

SHOPS AND YARDS.

In one of the wings of the structural mill building are located the machine shops and roll-turning shop.

Machine Shop.—The machine shop is fitted with all tools necessary for renewing and repairing the various machinery and furnaces of the several mills. The equipment includes 6 lathes, 1 slotter, 1 shaper and grindstone, 3 drill presses, 2 screw cutters, 1 boring mill, 1 planer; all driven by a 12 by 22 Hamilton engine.

In a separate building located near the 119-inch plate mill, in another part of the yard, is a 76-inch by 76-inch planer, with a 40-foot stroke. This is used for large castings and also for planing the edges of bridge plates. A special arrangement in connection with the planer admits of planing any length or width of plate that can be rolled in the mill.

In connection with the plate mill is a special machine shop, including 2 lathes, 2 shapers, 1 planer, 1 milling machine, 2 drill presses, and one wet grinding wheel for shear blades, besides a special planer for plates. In this shop the test pieces for the plate mill test room are prepared. In another shop where test pieces from the other mills are prepared are three small planers, one milling machine and one emery wheel. Roll-turning is done in a separate shop adjoining the machine shop, in four heavy lathes.

The blacksmith shop is located near the machine shop at one end of the structural mill, and consists of seven fires, supplied with a blast by a No. 8 Sturtevant fan; two steam hammers, and a small furnace to do the heating for the steam hammers. A pipe-fitting shop is also in this building.

The carpenter shop, pattern shop, tin shop, paint shop, and saw shop (where blades for hot and cold saws are straightened and prepared) are situated at one corner of the company's property, some distance from the mills and close to the river.

A very complete and thoroughly equipped laboratory is in connection with the works, in a brick building 40 × 90 feet, built for the purpose. Adjoining the laboratory is a smaller building in which a 200,000-pound testing machine, made by Olsen & Co., of Philadelphia, is located. A similar machine occupies a testing room in the plate mill.

By means of the laboratory and testing machines, a careful and thorough record of the analysis and physical characteristics of the steel produced is kept. All pig iron, scrap, spiegel, ferro-manganese, etc., that go into the manufacture of the steel (either bessemer or open-hearth) are analysed, and the product of the furnaces and converters are similarly treated.

In the testing machines, each plate, angle, flat, channel or beam (as the case may be) is tested by sample for tensile strength, elastic limit, reduction and elongation, all of which are recorded and filed away, with the analysis of the material. In addition to this, the material is subjected to all manner of tests, such as quenching and bending, bending cold, punching and drifting, or any other special tests which may be desired.

Yards.—The yard service includes three standard gauge engines which transfer the product of the mills to the tracks of the Pennsylvania Railroad, and six narrow-gauge engines of various sizes for carrying steel from mill to mill. There are nine miles of standard and narrow-gauge tracks in the works.

In addition to a number of hand cranes and hydraulic cranes about the yards, in the various shipping departments, there are four 10,000-pound and two 5000-pound Yale & Towne locomotive cranes, which assist in the handling and shipping of slabs and the transfer of ingot-moulds at the converting mill.

The water supply for the mills is derived from the Monongahela river.

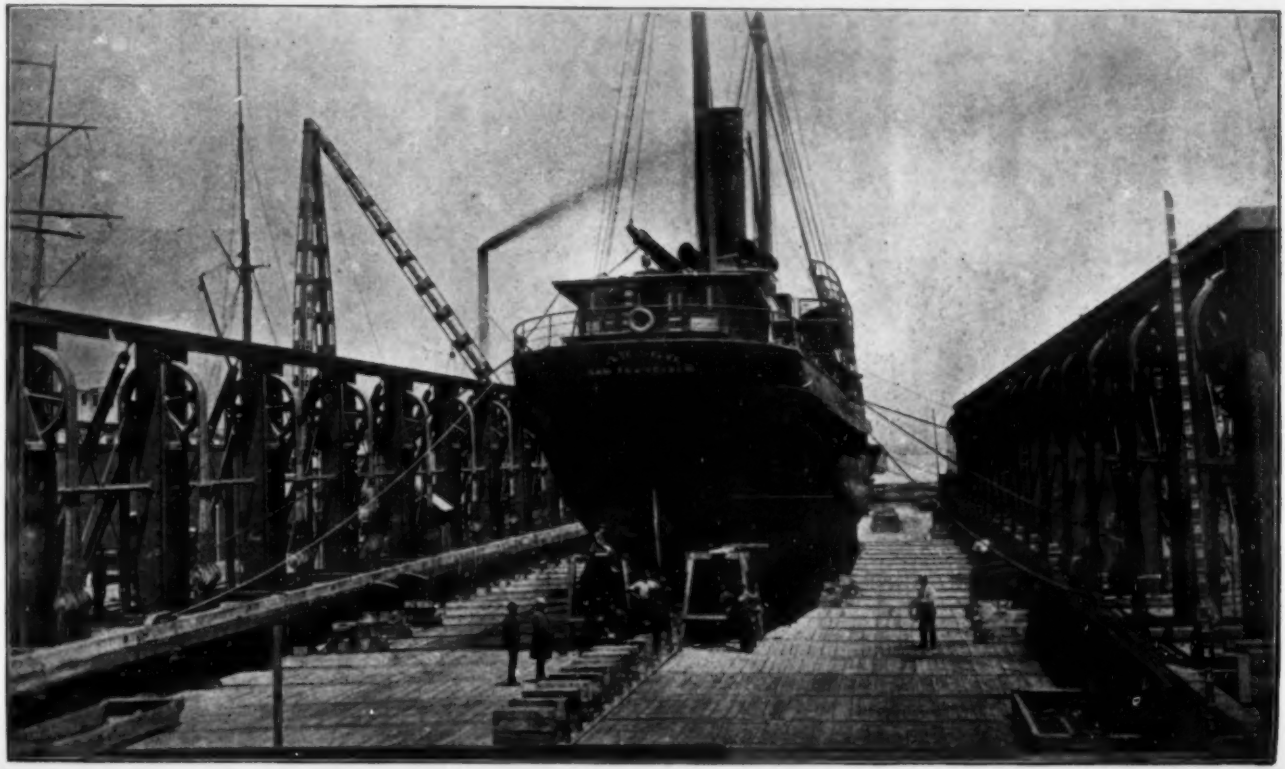
The plant at the water works includes four boilers, two compound duplex steam pumps (Wilson, Snyder & Co., 3,000,000 gallons per 24 hours), and two tanks.

SYSTEM OF THE WORKS.

The works are under the charge of a general superintendent. Each mill or department has its particular superintendent, under whom, in turn, are his various clerks and foremen. The mills are run night and day.

The offices of the various mill superintendents, shipping clerks, etc., are all connected with each other and with the general office by a system of telephones, to avoid delay and obviate as far as possible the necessity of sending messengers.

The yearly pay-roll amounts to, approximately, two millions of dollars. Number of men employed, 2500.



THE ARAGO.

First Steel vessel built on the Pacific Coast, and first vessel hoisted on New Hydraulic Dock U. I. Works.

To face page 443.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

SHIP-BUILDING AND ITS INTERESTS ON THE PACIFIC COAST.

By Lieut.-Commander F. P. Gilmore, U. S. N.

The Sitka, a small paddle-wheel vessel, was the pioneer steamer in the waters of the Pacific coast. She was built in the town of that name in Alaska, in 1847, was 37 feet in length, with 9 feet beam and 3½ feet depth of hold. She was brought to San Francisco on the deck of a sailing vessel, made her trial trip on November 15th, and, after short runs to Sonoma, Santa Clara, and Sacramento, she, after the discovery of gold, ran under the name of the Rainbow on the Sacramento river, and was finally lost in a gale while at anchor. The wreck of the Beaver, the first steamer that came into the Pacific from the south, now lies opposite Vancouver. She was also a paddle-wheel boat, and was for years in the service of the Hudson Bay Company in the Sound. She is not such a wreck but that she could be easily repaired.

With the exception of the Union Iron Works of San Francisco, all the ship-building yards on the coast are for the construction of wooden vessels, the Union Iron Works having the only plant for building deep-sea vessels of any size of iron or steel.

The abundance and accessibility of the timber on Puget Sound, with its tranquil waters, makes it a paradise for wooden ship-builders; and with its coal and iron mines, it promises to be the same for the steel ship builder. The durability of the Puget Sound timber was discovered during its extensive use for repairs. Its advantages are its great length, size, and lightness, and the tenacity with which it holds iron fastenings. Its cheapness was an offset against the high price of labor. There is now on the coast a large fleet of wooden vessels unrivaled for the lumber trade, and which challenge comparison with any other lumber fleet in the world.

Hall's ship-yard, opposite Seattle, is the only permanent one located on the Sound. The largest vessel yet built was the bark

Hesper, of 695 tons gross, but the yard has the capacity for building any-sized wooden ship. A steamer intended for trade on the Sound was lately launched at Tacoma. Small vessels are built at many places along the coast, principally on the Columbia and Willamette, and at Humboldt, Coos Bay, and Benecia.

A large industry in San Francisco is the building of steam schooners for traffic along shore. They are most of them engined, and many of them contracted for by the Fulton Iron Works. This firm has placed engines varying from 5 to 800 horse-power in about 80 of these vessels. The ferry-boat Eucinal has engines of 1200 horse-power. Another great interest in San Francisco is the steam whaling fleet. Out of 47 vessels sailing from this port in 1888, 25 are owned here. In 1884 the catch of the 6 steamers built and equipped in San Francisco was greater than that of the entire eastern fleet of 20 vessels sailing from this port and including their two steamers. The whaling fleet gives employment to 1800 men. What a nursery for a naval force!

As early as August in 1885 the Union Iron Works made proposals to build any of the cruisers then authorized by Congress. In that year was launched from this yard the Arago, the first steel steamer built on the coast for deep-water cruising. She is of 827 tons gross, is 200 feet long, with 30 feet beam, and a draft of 16 feet, and with engines of 450 H. P. The Fulton Iron Works claim to have built at an earlier date a small iron steamer, the Sucre, of 50 H. P.

Up to 1885 the vessels built on the coast were of wood. Since that date the Union Iron Works have built and launched the Charleston, 3200 tons; the Pomona, 1246 tons; the Premier, 1080 tons; and the tugs Collis, McDowel, and Active, all of steel. The San Francisco, of 4000 tons, is on the blocks, and the contract awarded for the coast-defense vessel authorized by the last Congress. The engines of these vessels were manufactured at the machine shops of the works, the steel, castings, and heavy forgings being made at the Pacific Rolling Mills. The launching of the Charleston marked a new era on the coast, the inauguration of a great ship-building trade. Encouraged by a well considered policy on the part of the Government, the wooden fleet on the coast, the vessels that are to carry our trade in the Pacific, and the cruisers and battle-ships of the Navy, can be built as expeditiously and as well as at any other yard in the country or world.

As given in the annexed table, during the year 1888 there were built at and about San Francisco 59 sea-going vessels, mostly for the coasting trade. The climate here is very favorable for the ship-

builder. During the winter of 1887–88 but ten days were lost on the Charleston because of the weather. Steel plates are never too cold to work or handle, nor in winter is half the time of a riveter lost while he blows his fingers. The summers are cool with no rain. The Pomona was contracted for with the Union Iron Works on September 14, 1887, and launched May 26, 1888. The Corona was contracted for with an eastern firm October 29, 1887, and was launched August 4, 1888. The former vessel cost $200,000, the Corona to cost $188,000, or $198,000 delivered in San Francisco. The Pomona is of 1264 tons gross, 951 net, and the Corona is of 1492 tons gross and 966 net. The Pomona has two boilers, the Corona four, and both vessels have triple-expansion engines. The Pomona will carry as much cargo as the Corona, and runs on 20 per cent less fuel, and she is the faster ship.

The company ordering these vessels had the use of the Pomona while the Corona was steaming around to the Pacific, and that trip is considered equal to a year's wear and tear in the regular work of the vessels. The above is cited only to show that the ship-builder on this coast can hold his own in material and workmanship.

Some interesting data was handed the writer lately of a steamer built when Thornycroft's reputation was young and the fast torpedo boat in its infancy. In 1876 the specifications for the iron steamer Meteor, to run on Lake Tahoe, called for a speed of 20 miles per hour. She was built and launched that year at Glenbrook, on the lake. The engines were built at Marysville, Cal., and all material and machinery were teamed over the mountains. There was no previous record of a vessel's steaming 20 miles per hour. The Meteor is 64 feet 6 inches long, with 10 feet beam, and a draft of 5 feet aft and 3 feet 1 inch forward, and a depth of hold of 5 feet. She is of 19.5 tons displacement, with fuel and 12 passengers on board, and is divided into water-tight compartments. The boiler is of steel, locomotive type, and carries 150 pounds pressure. The engines are one pair inverted cylinders, 10 inches diameter and 12 inches stroke, and weigh 2600 pounds with all fittings. The propeller is of brass, three-bladed, and finished all over. The Meteor made 21 miles per hour repeatedly over a measured mile, and from Glenbrook to Tahoe City she made 12 miles in 38 minutes, or 18.9 miles per hour. The engines made between 270–280 revolutions, and were designed and built by W. R. Eckart. The largest torpedo boat afloat in 1881 was built by Thornycroft for the Danish Government. She was of 55 tons displacement, with a coal capacity of 10 tons. At full speed, as

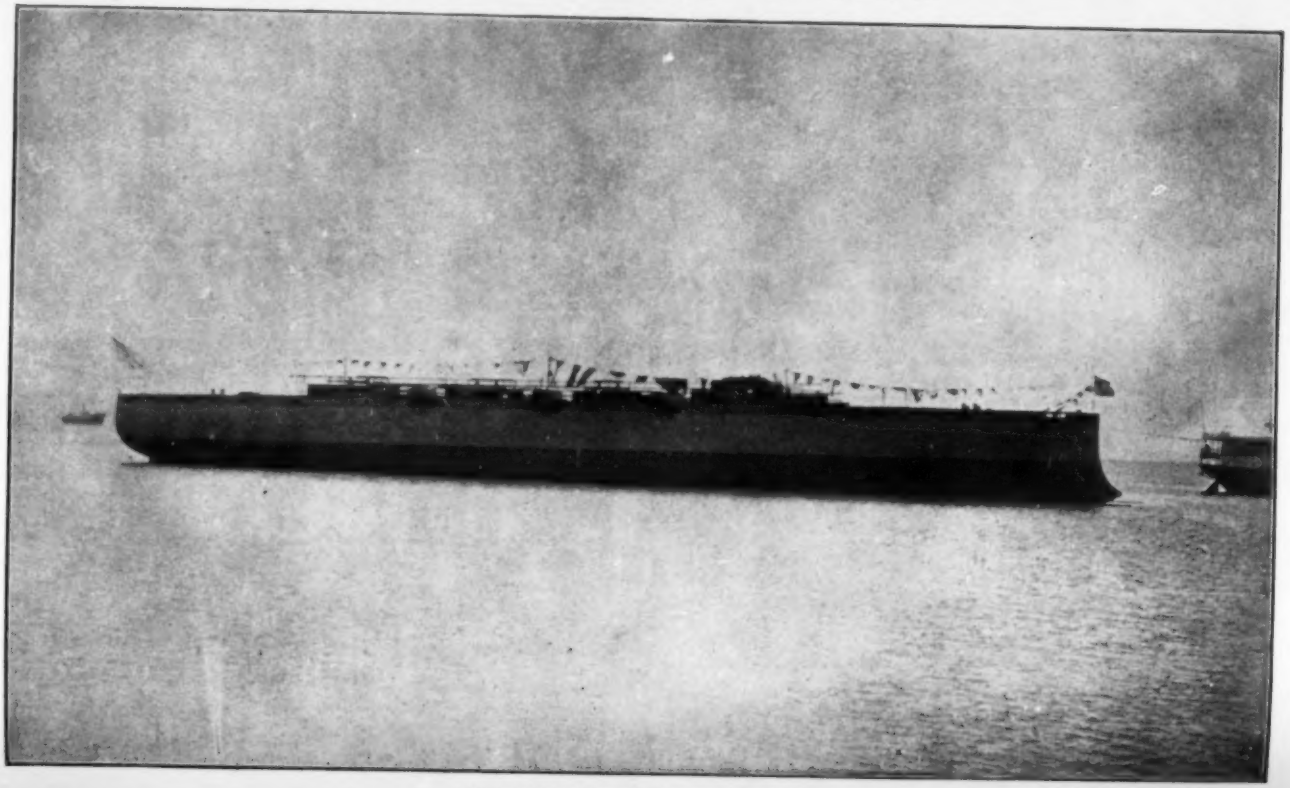
shown on trial as well as during a three hours' run on measured miles, she made 20 knots per hour.

What is most needed in San Francisco is an abundant and cheap supply of good coal. With this, even with the high price of labor, the shipyards here could compete with any in the world. Most of the coal comes from Australia and British Columbia. Mines are being discovered and opened at many places along the northern coast, and some reported very valuable are about being opened at Kenai in Alaska. The Kenai Company claims it can place coal in San Francisco at $3.50 a ton with 10 per cent profit. Of the 1,400,000 tons of coal received at San Francisco in 1888, nearly 700,000 tons were foreign and almost the whole of it transported by water. The importance of the absolute control of Puget Sound and the Columbia River, as well as the development of lines of supply between the two, needs no argument. At present, in case of war, San Francisco would be without coal at once, even if the whole coast were fortified. Efficient naval and merchant vessels are absolutely necessary.

The material for the steel vessels built on the coast is made and shaped at the Pacific Rolling Mills, and for quality is unexcelled. With its already extensive plant it would not be difficult for this firm to erect hydraulic forges that would turn out any shape for ship or gun. But it would have to be under a contract with the Government for a large enough order, running over some years, to remunerate the firm for its outlay. There are other firms in San Francisco ready to contract for building marine engines and boilers of any size. There is an abundant supply of good iron ore on Puget Sound. But in 1888 there were imported from Great Britain to San Francisco 18,393 tons of pig iron, against 2037 tons from the Eastern States and 1940 tons from the Coast furnaces. The principal reason for this is that grain ships bring the iron for ballast. The Port Townsend ore is excellent, and there is also good Bessemer ore in California.

Besides the Government docks on the coast at Victoria and Mare Island, there is a large dry-dock at Hunter's Point in San Francisco, and the new hydraulic dock at the ship-yard of the Union Iron Works.

There is in San Francisco to-day wealth to the value of $936,000,000. Three per cent of this sum is estimated by the Fortification Board as sufficient to place the harbor in a fair state of defense. The value of the cargoes cleared in 1888 was $836,736,000, increasing at a yearly rate of $20,000,000. All of this wealth is now exposed to easy capture in the event of war with a powerful maritime power.



THE CHARLESTON AFTER LAUNCH.

To face page 447.

In 1849, and before the days of iron ships, the United States was building wooden sailers of a better quality and at less cost than any other nation. At that date came the discovery of gold in California, and soon afterwards was the Crimean War. England took alarm at our success in ship-building, and permitted the registry of foreign-built vessels of any class. From 1858 to 1864 foreigners, principally English, purchased from the United States over 1,000,000 tons of shipping. At the close of the fiscal year, June 30, 1888, not one ship and but few other vessels were built in this country for the foreign trade. The true reason for this is that the United States has had enough to do with its capital in the development of the country, and with the Civil War and reconstruction. But the fault of Congress has been in not legislating so that ship-building and sailing the sea would be remunerative in spite of the opportunity for other investments. It is a most singular thing that all industries have been protected and developed except the one that from a national point of view is most important and most vital to the safety of the country. The delay has made the matter more difficult, but with proper encouragement we can regain our place as ship-builders for ourselves at least, if not for the markets of the world.

The aggressive policy of Great Britain must be counteracted by legislation either by subsidy or compensation for carrying the mails —call it what you will; by liberal contracts for the construction of war-vessels to encourage the private ship-yards, and by the payment of fixed sums to contractors who will construct merchant vessels to conform to plans prepared by the Secretary of the Navy, so that such vessels can be utilized as cruisers in time of war; and by the establishment of a system of inspection the least expensive and only sufficiently severe to obtain the best material and workmanship.

The policy of Congress in relying upon our own ship-yards is, so far as it goes, not open to criticism. The free-ship theory has now but few advocates. The danger of relying upon foreign ship-yards seems patent, risking as it does our commercial independence and national security.

There is a direct effort now being made to divert American business to Canadian cities, and the proposed military works at Victoria, Vancouver, and Halifax mean a determined grasp on the part of England for supremacy in the Pacific. It is absurd to state that all this work in Canada is intended to counteract the fortifications of Vladivostok, or that the Canadian Pacific Railroad is simply intended as another highway to India. This road has been subsidized with

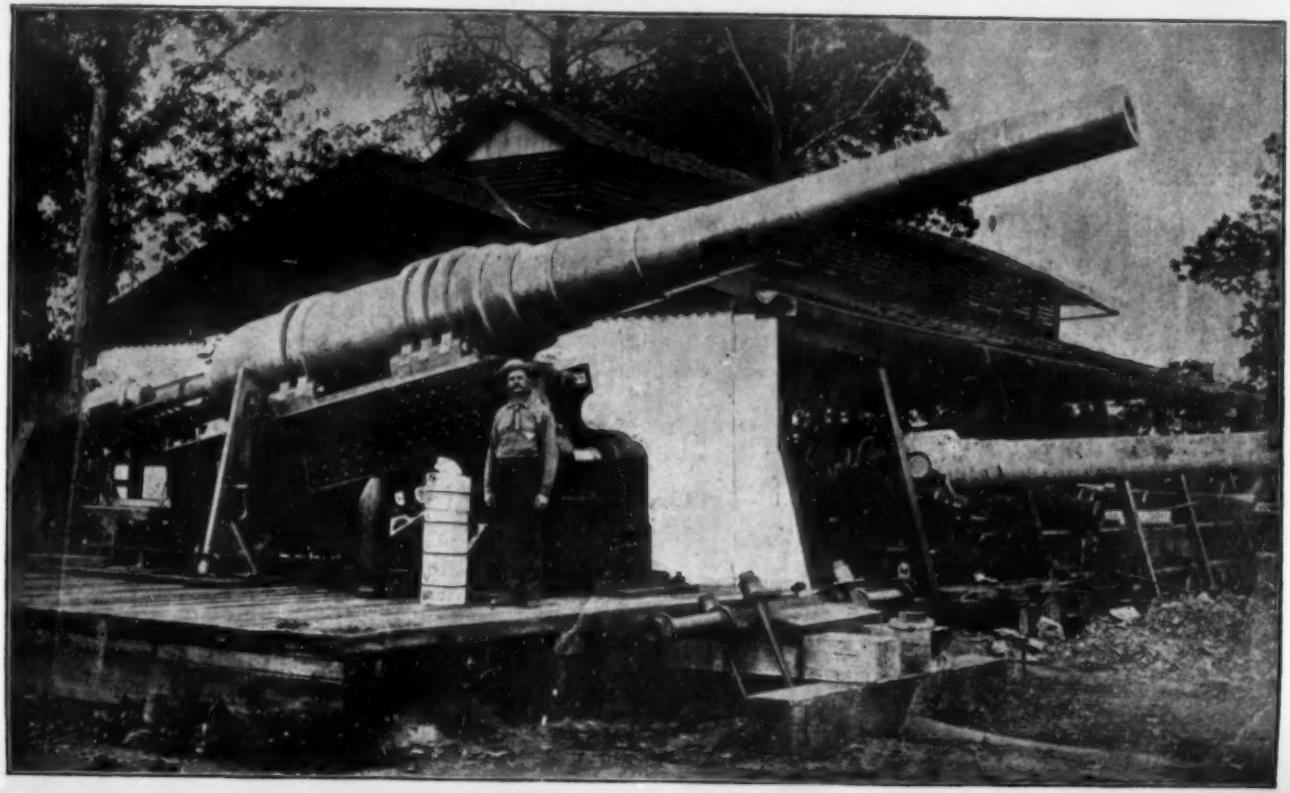
about $215,000,000, and its steamers to China receive $300,000 a year. The steamers being built receive also Admiralty subsidies. We owe England nothing but the prolongation of the late war, and the vagaries of a few of our dudes, and her movements in the Pacific require our earnest attention. The Canadian Pacific Railroad is a great military and political work, as well as civil, and unless its influence is met by proper legislation, military and commercial, we might as well make up our minds to pay tribute to Great Britain on all our trade in the Pacific. We are not certain of always finding a market for our grain. The country is restive for proper legislation to enable it to find markets abroad, and transportation of its own, for the products of its manufactories.

The policy of distributing contracts for government vessels in private yards is one from which the greatest advantages are derived. It will accumulate plant that will not only furnish the best and fleetest models of marine architecture for our own naval and merchant marine, but, with the genius of the country at work, we shall in a short time be as independent of the world in building steamers of steel as we were in 1849 with sailers of wood. The navy yards should be used as arsenals, and perhaps for repairs, and turned over to the marines at night for safekeeping. Private invention and enterprise properly encouraged, with rash experiment controlled by systematic inspection, will always be ahead of government work. And in a private ship-yard you can always tell what a vessel is going to cost.

With the high-power long-range guns now in use, a battle-ship being able to choose her position, has somewhat the advantage over forts or batteries on shore. Torpedoes can be destroyed, and with us for coast defense the fort must be auxiliary to the fleet. Germany has turned the defense of its coast over to its navy, and some of the ablest military minds in England advocate the abandonment of many fortifications, trusting the defense of the coast to the Channel Squadron. An enemy's fleet must be met by coast-defense vessels and torpedo-boats, and, with the magnitude of the undertaking to fortify a coast like ours, the batteries on the *movable* battle-ships must be depended upon to keep an enemy from entering our ports. Internal lines of water communication should be constructed along the Atlantic seaboard, and from the Mississippi to the great lakes; and the Intelligence Offices of the two services should perfect their plans for the transportation in time of war of coal from the great Northwest for the fleet that will rendezvous in the Bay of San Francisco.

Statement of Entire Tonnage Built on the Pacific Coast, U. S. A., during the years ending June 1860 and 1888, both inclusive, as per ~~U.~~ S. Reports on Commerce and Navigation.

Year.	California.				Oregon.				Washington Territory.			
	Steam.		Sail.		Steam.		Sail.		Steam.		Sail.	
	No. of Vessels.	Whole Tonnage.	No. of Vessels.	Whole Tonnage.	No. of Vessels.	Whole Tonnage.	No. of Vessels.	Whole Tonnage.	No. of Vessels.	Whole Tonnage.	No. of Vessels.	Whole Tonnage.
1860.....	8	(both) 2,023.23	23	.....	.....	.....	.....	.....	.....	.....	.....	.....
1861.....	7	(both) 4,715.71	42	.....	.....	.....	.....	.....	.....	.....	.....	.....
1862.....	6	(both) 2,524.26	22	.....	.....	.....	.....	.....	.....	.....	.....	.....
1863.....	6	(both) 2,670.67	26	.....	.....	.....	.....	.....	.....	.....	.....	.....
1864.....	11	(both) 4,852.50	42	.....	.....	.....	.....	.....	.....	.....	.....	.....
1865.....	8	(both) 2,815.57	29	.....	.....	.....	.....	.....	.....	.....	.....	.....
1866.....	13	(both) 5,495.59	1	.....	.....	.....	.....	.....	2	(both) 628.29	5	.....
1867.....	9	(both) 4,323.77	31	.....	.....	.....	.....	.....	.....	.....	.....	.....
1868.....	8	2,212.52	33	2,493.01	.....	.....	3	126.59	2	58.16	2	408.09
1869.....	14	1,982.11	58	7,938.07	9	1,517.00	8	265.48	4	343.84	15	1,668.26
1870.....	18	3,179.58	49	5,207.08	11	830.74	4	63.28	4	315.88	9	1,033.96
1871.....	4	1,603.84	12	808.18	7	2,134.25	7	139.71	2	122.78	3	22.39
1872.....	2	253.54	8	414.45	5	693.63	2	80.82	1	161.54	4	302.45
1873.....	7	1,510.47	20	1,371.49	5	1,316.17	2	31.25	2	214.76	7	538,59
1874.....	9	1,764.27	23	4,625.65	7	278.45	4	86.68	.....	.....	13	2,223.74
1875.....	14	1,981.54	29	3,764.87	11	1,559.55	.....	.....	3	409.90	9	2,773.78
1876.....	14	4,844.69	49	3,712.10	14	3,957.63	5	1,335.62	3	166.15	13	2,142.91
1877.....	10	1,337.13	35	3,447.86	11	3,329.80	11	254.86	3	227.82	10	2,764,98
1878.....	10	4,121.24	23	1,702.98	11	4,234.21	7	182.75	1	5.08	5	631.74
1879.....	12	2,853.10	18	1,007.02	11	5,429.55	5	697.28	6	489.58	7	375.08
1880.....	7	4,948.85	11	846.31	13	2.027.40	2	75.17	5	666.36	2	15.96
1881.....	5	1,358.62	21	3,197.08	13	1,616.50	7	1,689.46	3	35.29	7	2,495.61
1882.....	11	3,620.53	25	3,377.09	10	2,699.81	10	2,135.90	7	407.01	11	3,530.18
1883.....	11	2,408.06	41	6,638.51	14	878.09	5	1,690.04	9	732.12	10	3,218.39
1884.....	..	5,137	Built and documented in San Francisco sail and steam.									
1885.....	..	5,373										
1886.....	..	4,147										
1887.....	..	17,629										
1888.....	..	21,921										



To face page 451.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE NAVAL ORDNANCE PROVING GROUND.

By Lieutenant Albert Gleaves, U. S. N.

Previous to 1872, most of the experimental ordnance work of the Navy was done at the Washington yard, and tests of powder were made there also, or at the powder yards, forts and arsenals.

In 1873, at the suggestion of Lieutenant-Commander Marvin, since deceased, the Government secured the lease for 99 years of a tract of land, comprising about 85 acres, on the Severn river, opposite Annapolis. The site was well adapted for the work on hand and in contemplation at that time, but, as will be seen, with the long range guns and the multifarious ordnance tests and experiments with high explosives which have attended the development of the new armament, the location of the Ground is in the highest degree unsuitable. Congress has appropriated $40,000 for the purchase of a new site, but the Bureau of Ordnance has not yet succeeded in finding a desirable place, although diligent search has been made.

The Ground is situated on a peninsula, the southern point of which is about 1000 yards from Greensbury Point lighthouse. The line of fire is directly down the bay, and it is impossible to exaggerate the disadvantages of the over-water range. In the winter months the range is obstructed by oyster boats, and the rest of the year by crabmen and pleasure parties from the neighboring summer resort at Bay Ridge. Unfortunately, the weather most favorable for firing down the bay is also that for these small craft, and the consequence is frequent long and tedious delays. It is obvious that ranging the new guns has been done under circumstances most trying to patience. It is only under exceptional circumstances that loaded shell can be fired over the range for testing fuzes; and the recovery of the shell for the purpose of examining the band or noting the action of the

percussion fuzes is entirely precluded unless they are fired into the butt. The proximity of the lighthouse on Greensbury Point and the large hotel at Bay Ridge, and the danger to life and property from projectiles which occasionally escape from the butt, are further reasons why the present site of the Proving Ground should be changed.

The principal features of the station are the chronograph house, machine shops, Hotchkiss, velocity and range batteries, explosion chamber, small arm range, and the butt. A brief description of each will not be inappropriate.

The chronograph house contains three Boulengé instruments, and is at a sufficient distance from the batteries to protect the chronographs from the concussion of the heavy guns. The chronographs are mounted on heavy oak pedestals which rest on solid foundations of concrete and granite. The three instruments are used simultaneously when observing velocities from the heavy guns, but usually only one is placed in circuit with the Hotchkiss battery. It is the rule of the station to throw out a reading which differs as much as twelve feet from the mean of the other two.

The machine and carpenter shops, the forge, the engine and boiler rooms are under one roof. The machine shop contains three lathes, two planers, and the usual outfit of machinist's tools.

The Hotchkiss battery is located a few yards from the chronograph house, and is simply an uncovered heavy oak platform to which are bolted the mounts of the revolving and R. F. guns. In front of this battery are two small sand butts, one for catching the projectiles when firing for velocity, and the other when firing at plates.

The velocity battery is the main battery of the Proving Ground, and upon it the heavy guns are mounted for proof, testing powder, armor trials, and other work except ranging. The platform is made of heavy oak beams braced with horizontal diagonal wooden braces and strongly anchored to condemned guns and old armor plates. It is 28 feet above mean low water. The first gun, a 12-pounder howitzer, was fired from this battery on the 16th of April, 1873. In the following month the battery was completed and a 15-inch shot with a charge of 60 pounds was fired into the butt. The butt is thrown up 300 feet in front of the platform and runs parallel with it; it is 100 feet long, 40 feet high, and 69 feet thick; this thickness is sufficient to retain a 10-inch projectile fired with full service charge.

The range battery, erected on the site of Old Fort Lot, is near the water's edge on the bay front. It is used for ranging, principally, and has attached to it one set of velocity screens. It has an unob-

structed line of fire down the bay. The explosion chamber is sunk in the side of the hill near the creek. Its walls, floor and roof are constructed of iron plates. A narrow tunnel leads to the entrance, which is a turret gun-port. Gas escapes are provided. The chamber is used for bursting loaded shell at rest when it is desired to observe the effects of bursting charges or the numbers and characters of the fragments of a particular kind of shell. The shell is suspended from an eye-bolt in the roof, fitted with an electric fuze and exploded by a Farmer's dynamo.

The magazine, which usually contains from 20,000 to 30,000 pounds of powder, is on the bank of the creek some distance in rear of the velocity battery. Near it is the filling house where the cartridges are made up.

In the "howitzer house," once the deck-house of the Saratoga, are stored the spare articles, and recently a flying shed, open to the southward, has been erected for sighting the guns, a work sometimes done at the station by mechanics from the Washington yard.

The dynamite house is a small brick building placed in a remote corner of the grounds. In it are kept dynamite, wet and dry gun-cotton, and the fulminate of mercury igniters.

The small-arm range extends diagonally through the grounds and is 700 yards long. Concrete platforms are erected at intervals of 100 yards, and in testing small-arms for accuracy the gun is mounted in a rest placed on the platform. The target is 10 feet x 15 feet and is laid off in 6-inch squares, with several circles grooved in the center.

There is a Cobb dock on Little Carr Creek, and a channel has been buoyed for the entrance of scows and barges with heavy material.

There are no cranes, derricks, heavy transporting trucks or any of the facilities for handling and purchasing heavy weights; all such work is done with the meagre resources of the station, but under the intelligent and capable supervision of the gunners attached to the station, remarkable time has been made in transporting guns, etc., using manual labor assisted by such sailor-like devices as have been from time to time suggested by necessities constantly arising. With nothing but jacks, hawsers, and gun-wheels, two horses and the laborers—usually about 45—the 10-inch gun No. 1, weighing 55,000 pounds, was gotten out of the scow and parbuckled up the hill from the dock in about 24 working hours. This time was further improved when 10-inch gun No. 2 was landed and hauled to position in 12 hours. A 6-inch gun weighing 11,000 pounds has been dismounted from its carriage and another mounted in a little more than one hour,

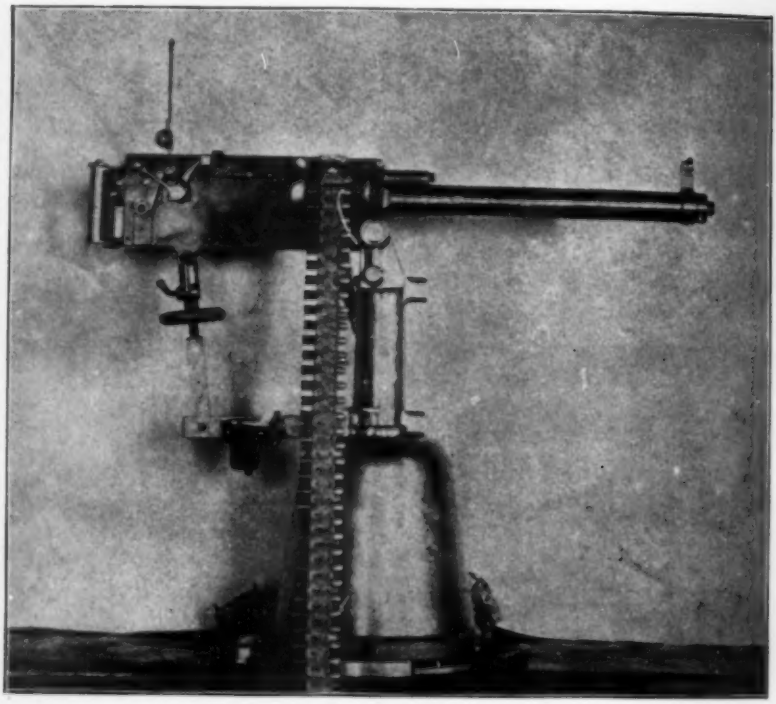
using an improvised derrick. Heavy armor plates are handled in the same way, transported, lifted, and secured in place by means of jacks and tackles. In mounting 10-inch gun No. 1 on the turret carriage it was necessary to jack the gun up 13½ feet above the ground, roll it in position over the slide, and then lower it in place. As there is only a play of .02 inch between the straps on the gun and the lugs on the slide, the greatest care was necessary, and it was accomplished without accident, in two days.

The station was originally known as the Naval Experimental Battery, but the development of the new armament made the station something more than experimental, and in 1884 the name was officially changed to Proving Ground. The work of the station embraces the test and proof of service and other guns, ranging, test of carriages and mounts, projectiles and powder, trials of armor plates, ballistic tests of castings, experiments with high explosives as applied to powder guns, tests of primers, fuzes, ammunition returned from ships, etc.

PROOF OF GUNS.

Guns when finished at the Washington yard or at other foundries are sent to the station to be proved before issue to service. The 6-inch guns are sent by rail to Annapolis, hauled through the town, and taken across the river on a scow. The heavier guns are sent all the way by water. The Bureau requires four rounds to be fired with service charges and projectiles brought up to weight; the chamber pressure to be 15 tons per square inch, and the initial velocity of the projectile 2000 f. s. The gas-check disks and pads are fitted during proof. The gun is star-gauged before and after proof, and it may be interesting to note the fact that often after proof the chamber of the gun is *smaller* than before, sometimes by .001 in. or .002 in. This may be due either to the stretching of the tube longitudinally or to the closer grip which the jacket and A hoops are supposed to exert upon the tube when they recover from the transverse expansion caused by the pressure of gases in the chamber. The statutory test of ten rounds, fired as rapidly as possible, is applied to only one gun of each caliber. As yet none of the new guns have been tested to destruction.

Besides the proof of service guns, trials of special types which from time to time have been sent to the Proving Ground, have been conducted and the various systems submitted to exhaustive tests. Among these may be mentioned the Maxim machine-gun of .45 caliber, the Driggs-Schroeder 3-pounder and 6-pounder rapid-fire guns, and the cast-steel guns.



MAXIM MACHINE GUN, 45 CALIBER.

DRIGGS-SCHROEDER RAPID-FIRE GUN.

To face page 455.

A good idea of the general arrangement and appearance of the Maxim gun is given by the photograph. The length of the gun over all is about 3½ feet, and the height of the trunnions from the base of the reservoir is about 3 feet. It may be said to consist of three principal parts: the barrel, the box containing the loading and firing mechanism, and the reservoir. As is well known, the principle of the gun is the old one of utilizing the recoil for loading and firing; its action suggests perpetual motion. The barrel is enclosed in a water-jacket automatically fed from the reservoir by the firing of the gun. The reservoir holds sufficient water for eight minutes' steady firing, or 4800 rounds. The water is kept under a pressure of two atmospheres. The square box in rear contains the mechanism, which is very simple, but unnecessary to describe here. The gun is fed from a belt which holds the cartridges. To throw the gun in action it is only necessary to enter the belt and press the firing springs on the rear face of the box, and the firing will continue as long as the spring is kept pressed down. The entire action is automatic; the cartridges are taken from the belt, forced into the barrel, fired, withdrawn, and ejected by the recoil of the gun; by tailing on belts the gun will fire as long as desired. It will be observed that if there is a miss-fire the whole action ceases, obviating all danger of accident from "hang-fires." During action the only motion visible is the in and out motion of the end of the barrel outside the water-jacket, the rapid forward and reversed motion of the bell-crank lever on the side of the box, and the steady advance of the belt across the reel. The gun is a marvel of simplicity and ingenuity and possesses many advantages. It has not yet been adopted by this government. It was tested at the Naval Ordnance Proving Ground last year. 3000 rounds were fired continuously, and the action noted for failures to fire, effect of heating, range, of rapidity of fire, velocity, accuracy as compared with the short Gatling, and its volley-power as compared with the same gun, and, finally, its endurance under the sand test. A new type of the Maxim rifle caliber gun has recently been tested at the Proving Ground, together with a 1-pounder R. F. gun. The new gun differs from the old principally in having a much larger cooling-chamber or water-jacket, which does away with the reservoir. This jacket holds about 2½ quarts of water, which is sufficient for the gun to discharge 1000 rounds in quick succession, but if fired in volleys the supply will suffice for 2000 rounds. The Maxim .45 caliber fires 600 to 700 rounds per minute. At the N. O. P. G. last June the Maxim 1-pounder discharged 100 rounds in 43.3 seconds.

The Driggs-Schroeder 3-pounder and 6-pounder R. F. guns have been tested at the P. G. with excellent results, and promise to become a formidable antagonist of the Hotchkiss guns which have for so long held the field undisturbed. The 3-pounder fired at the rate of 23 rounds per minute and the 6-pounder discharged 19 aimed shots per minute.

The Driggs Ordnance Co. have received a contract from the Bureau of Ordnance to apply this breech mechanism to the new 4-inch and 6-inch R. F. guns building at the Washington Navy Yard, and they have also received an order for a 6-pounder for the army.

RANGING.

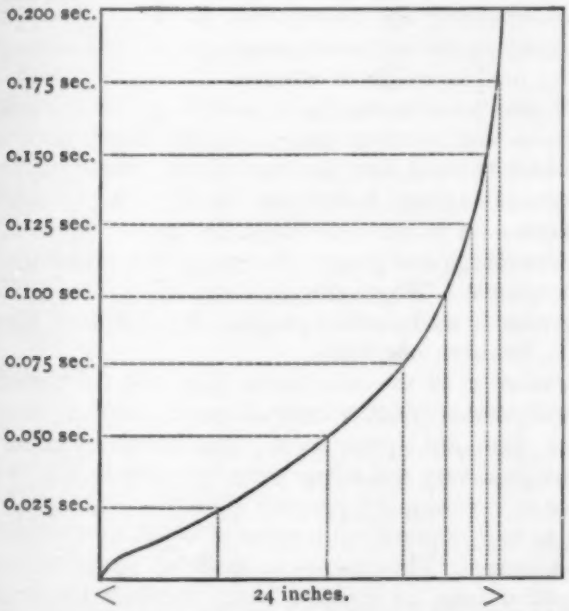
Two range tables are computed for each caliber of the new guns, one for an initial velocity of 1700 f. s., the other for 2000 f. s. The data for the computations is obtained by actual firing in the following manner:—The quadrant angle is calculated for ranges, say as in the case of ranging the 8-inch B. L. R., initial velocity 1700 f. s. for 3000, 4000, 5000, and 6000 yards. The gun is laid by gunner's quadrant, and about five shots are fired under service conditions at each of these elevations, the jump being observed, if possible, at each round. One observer with theodolite in rear of the gun observes the deflection of the splash from the line of fire, another notes the time of flight with a stop-watch, while three observers at stations on the shore line of the bay angle on the splash with plane tables. The "firing data" thus obtained is worked up into the range tables by Siacci's method. The table must contain the angle of elevation, height of sight-bar, time of flight, deflection, angle of fall, and remaining velocity for every 100 yards; the height of sight-bar for every ½ second of time of flight, and the range and height of sight-bar in inches for every 30 feet of elevation.

TEST OF GUN CARRIAGES.

Gun carriages are tested for strength, rigidity and steadiness; the length, velocity and general character of the recoil and counter recoil, the amount and character of the strains on the deck circles, pivots, clips and rear trucks; the time required for loading, firing and training through various arcs; the behavior of the carriages when firing at extreme elevation and depression. To determine the velocity of recoil, a simple and ingenious instrument called a velocimeter has been designed by Ensign R. B. Dashiell, U. S. Navy. It

To face page 457.

consists of a frame supporting a heavy paper-covered cylinder 30 inches long and 12 inches in diameter, which revolves on its axis in accurate journals on the frame-work. Sliding on the frame and tracing an element of the cylinder when at rest, is a pencil which is connected with the gun by an iron rod in such a manner that any movement of the top carriage will give the same movement to the pencil point. The cylinder is revolved by a cord and falling weight, and its velocity of revolution is measured by noting with a stop-watch the time required for the weight to fall a fixed distance. At the lowest point of fall reached by the weight is a trigger by which the gun is fired and the acceleration is thus removed from the revolving cylinder simultaneously with the beginning of recoil, so that during the short interval of recoil the velocity of revolution may be considered constant. A curve is thus obtained from which the velocity of recoil can be measured at any point. In the diagram, a curve of recoil of a 6-inch gun is shown. The horizontal lines are distances travelled by the gun in the times indicated by the corresponding dotted lines.



DEVELOPMENT OF CYLINDRICAL SURFACE OF RECOIL VELOCIMETER.

Curve of Recoil 6-inch B. L. R. on Broadside Carriage.

Several different types of gun-carriages have been tested at the Proving Ground, the gravity return system giving the best results. The 10-inch turret mount (hydraulic) is still under trial, and experimental firing has been done with the 8-inch B. L. R. on a pneumatic carriage.

POWDER.

Brown prismatic powder is used in all the heavy guns, black square grain powder in the rapid-fire guns, and fine grain black powder in the revolving cannon. These powders are manufactured by the Duponts at Wilmington, Del. At the Proving Ground all powder is submitted to two tests, one to ascertain its ballistic qualities and the other its physical properties. The specific gravity as a rule is determined at the powder yard, but it is occasionally verified at the Proving Ground. Mallet's densimeter is used for fine grain powder, and Dupont's densimeter for prismatic powder. The gravimetric density of fine grain powder only is taken. The amount of moisture it contains is determined by noting the decrease in weight of a certain amount which has been left in the drying stove until its weight is constant. Conversely its capacity for absorbing moisture is obtained by observing the increase in weight of a certain amount left in the water box until its weight is constant.

The ballistic qualities of a sample of powder are determined by the chronographs and pressure gauge. In the heavy guns three crusher gauges are screwed into the face of the mushroom, but in the rapid-fire guns one gauge is dropped loosely into the cartridge case. Sometimes — as in the 1-pounder, the case of which is too small to hold the charge and gauge—the gauge is screwed into the base of the projectile. When this is done, 50 per cent of the observed pressure must be added to give the chamber pressure. This method is, however, unreliable.

The specifications of all the new heavy guns and the 3-pounder rapid-fire gun require an initial velocity of 2000 f. s. with a chamber pressure of 15 tons per square inch. The specifications for the powder of other guns vary according to the type of gun, but 15 tons per square inch is the maximum pressure allowable in any gun.

In testing a sample of powder it is usual to begin by firing about half the service charge. The charges are made up by hand, and the operation is rather long, 15 minutes being required for a 6-inch charge and about 25 minutes for an 8-inch charge of 126 lbs. The pressure and velocity obtained from this round serve as a guide by

which to work up to the required velocity and pressure, using Sarrau's formulæ:

$$\frac{V}{V_1} = \frac{(W)^{\frac{1}{3}}}{(W_1)^{\frac{1}{3}}}, \tag{1}$$

$$\frac{P}{P_1} = \frac{(W)^{\frac{1}{3}}}{(W_1)^{\frac{1}{3}}}, \tag{2}$$

and frequently the second round shows whether the powder is likely to fill the specifications.

The development of powder for the new guns has been carried on at the Proving Ground. In 1884 the Duponts succeeded in making the first satisfactory brown prismatic powder which gave as good if not better results than the German powder. The powders for the 5, 6 and 8-inch calibers have been determined, but that for the 10-inch is still in the experimental stage.

The record of official powder samples is kept by a system of letterings in such a way that if the letter of the powder is known, the gun for which it is intended is also known. The P. V. A., P. V. B., etc., are 5-inch powders, O. P. A., O. P. B., O. P. C. are 6-inch, and R. G., R. G. A., R. G. B., 8-inch. These letters are not abbreviations and have no other significance than to designate the powder for a particular caliber.

The bursting of the gun on the Admiral Duperré has raised the question of the effect of continued high temperature on brown powder —the supposition being that when the moisture is dried out the powder becomes very much quicker. The subject will soon be investigated at the P. G. A box has been constructed, the temperature of which will be maintained at 140° F. The I. V. and the pressure of a sample of powder will be determined before it is stowed in the box, and again after it has been subjected to the high temperature for several months.

TEST OF PROJECTILES, ARMOR PLATES, PRIMERS, FUZES, ETC.

Projectiles are tested with reference to temper, toughness, action of band, shape of head for various work, character of flight, etc. Cast-iron, cast-steel and chrome-steel shell have been tested in the new guns. In January, 1889, an 8-inch tempered steel shell was fired against a 10-inch compound (Cammell) plate. The plate was 298 feet from the muzzle of the gun, and the striking energy of the projectile was 6794 foot-tons. The projectile pierced the plate, but

broke up, all the fragments remaining in the plate and backing. The head of the projectile was considerably upset. The hard face of the plate was broken off around the impact to a depth of one to two inches. Seven large cracks were opened. The appearance of the plate is shown in the photograph.

Plates and shields are tested for resistance when tempered by different methods. The ballistic test of armor plates of more than 6 inches is in general terms the following: The plate will be bolted to wooden backing of 36 inches. Near the middle of the plate will be laid off an equilateral triangle, the length of each side being 3½ calibers of the gun to be used in the test. The velocity of the projectile will be such as gives by calculation sufficient energy to pass through a wrought-iron plate and its wooden backing; the wrought-iron plate being supposed to be equal in thickness to the test plate. No projectile nor any fragment of the plate must get wholly through the plate and backing. The plate must not break up and pieces be displaced so as to expose the backing before the impact of the third shot; neither must very large cracks which expose the backing appear before the impact of the third shot.

The action of fuzes is observed with reference to their safety, liability to prematures in the bore, and for sensitiveness to explode on ricochet. Primers are tested for certainty of fire, leaks, and liability of fouling or spiking the vent.

EXPERIMENTS WITH HIGH EXPLOSIVES.

These have been of a tentative character, principally with the object in view of settling decisively the question of the safety of using wet and dry gun-cotton as a burster in shell fired from powder guns, and have included the experiments with the Torpedo Station mixture known as "Explosive A" and the Smolianinoff "inert" nitroglycerine. It is pretty certain that wet gun-cotton can be safely used as a bursting charge, but the question is still an open one.

"Explosive A" was a liquid which was poured into the shells. Eight rounds were fired successfully from the South Boston 6-inch steel gun; the ninth shell exploded in the gun, destroying the gun and wrecking the carriage.

The Smolianinoff experiments were discontinued after three rounds from the 8-inch M. L. R., as the last shell exploded unexpectedly on impact with the water.

PHOTOGRAPHY.

Photography forms an important part of the work at the Proving Ground, and is used almost daily to illustrate the official reports of the Inspector.

In 1884 an important modification was made in the English method of photographing the bore of a gun, by which pictures were obtained of desired points of normal size. This was accomplished by inserting the camera itself in the bore, whereas the foreign method was to photograph from the extremity of the gun, the camera being placed either at muzzle or breech, an arrangement which necessarily gave very small images on the ground glass. Experiments have been made to photograph a projectile at the instant of impact against a plate, but as yet have not been successful.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

GUN-COTTON—ITS HISTORY, MANUFACTURE, USE.

By Lieut. Karl Rohrer, U. S. N.

[Reprinted from *Scientific American.*]

The explosive of this name was discovered in 1833 by Bracounot, who dissolved paper and starch in concentrated nitric acid, and recovered a powdery white substance, which burned with a flash when brought in contact with flame.

Pelouze, about the same time, observed that starch so treated gained in weight. He also noticed that by dipping cellulose matter in nitric acid of 1.5 sp. gr. it became very inflammable.

In 1846, Schonbein announced the discovery of a new explosive, having four times the power of gunpowder, and as being eminently suited to take its place as a propeller of projectiles and in explosive work generally.

Almost simultaneously, Bottger succeeded in producing what he called explosive cotton. He combined with Schonbein to practically utilize their joint discovery.

Otto succeeded in producing gun-cotton independently of Schonbein and Bottger, working up from Pelouze's published experiments. Otto's product was weaker than Schonbein's, as he only used nitric acid in its preparation, and not mixed nitric and sulphuric acid, which the latter used. The publishing of Otto's experiments and their results led many expert and amateur chemists to investigating in this field.

Knop, Heeren, and Karmarsch discovered that the best gun-cotton was produced by dipping cellulose in the mixed acids, nitric and sulphuric, a fact which was the secret of Schonbein and Bottger.

Publishing and discussing the various ways of producing gun-cotton created great excitement in the scientific world of that day.

As a humorous scientist put it, "The current literature breathes gun-cotton, and the consumption of nitric acid is colossal."

In the meantime efforts were made in France, Russia, and England to introduce gun-cotton and substitute it for gunpowder. But the processes of manufacture and the impurity of the raw materials used were such that the results were unsatisfactory. Fatal explosions occurred in France and England in 1848. The political revolutions of that time drew further public attention from the subject.

An Austrian officer, Captain Von Lenk, by study and investigation, succeeded in producing gun-cotton which excelled all its predecessors in the regularity of its effect and in its keeping properties. Experiments with it from 1849 to 1853 tended to justify faith in its future, and the Austrian government bought the Schonbein-Bottger patents.

In 1853 the first gun-cotton factory established and worked upon a rational plan was erected at Hirtenberg, near Vienna, under Von Lenk's superintendence. His method of manufacture was kept secret until 1862, when he gave it to the French and English, and patented it in the United States in 1864.

In 1865 the Austrian government abolished the use of gun-cotton in its service because of two fearful explosions of magazines filled with it, the cause of which could not then be determined.

In this year Abel made the discovery which took gun-cotton out of the realm of possibly useful explosives and placed it in that of the safe, practicable, effective and useful ones. This consisted in pulping it, to admit of its proper purification, and in compressing it to increase its explosive effect. Upon the Von Lenk-Abel method all gun-cotton is now produced. Essentially, this method is to dip good and thoroughly cleansed cop or weaver's waste in pure and strong mixed nitric and sulphuric acid—one part by weight of the former and three parts by weight of the latter; to wash, boil, pulp, and liberate the resulting gun-cotton from all free acid; then to mould and compress it into the desired shapes and sizes for use.

For the manufacture of gun-cotton in the factory established at the naval torpedo station and war college (Fort Wolcott) in 1883, the cotton used is cop or weaver's waste, which is received in bales of about 500 pounds each. The bales are opened, and the cotton is picked over and placed in the cotton boiling tubs, about 200 pounds in each tub, to which is added about 250 gallons of water and 35 pounds of caustic soda. The cotton is boiled in this solution for eight hours, then drained over night; it is then boiled for eight hours in

clear water, again drained, and then thoroughly washed in a centrifugal wringer or extractor. It is thus freed from oil and other impurities.

It is then spread on the wire netting shelves of a suitably arranged dry room, through which hot air, at about 180° F., is circulated, and is sufficiently dried to be picked.

The cotton as received in the bales is full of knots and rolls, and the boiling adds to them. To prepare it for conversion into gun-cotton, it is necessary to take them out, that the acid may penetrate easily and quickly through all parts of it. To accomplish this result, the cotton is passed through a picker, a machine common to all cotton factories.

Having been opened out by the picker, it is dried as thoroughly as possible. This is done by placing it in the wire-netting-bottomed drawers of a specially constructed drier, that is closed when filled, through which, and its contents, hot air at about 225° F. is driven by a Sturtevant blower, which draws its air through a steam heater. In this drier it is left for eight hours, at the end of which time it is estimated that not more than ¼ to ½ of one per cent of moisture remains. Water is liberated by the action of nitric acid upon cotton, and to avoid weakening the former any more than is absolutely necessary, and to prevent dangerous increase of temperature, the latter must be as dry as possible.

When dry the cotton is stowed away in powder tanks, so that it may be conveniently handled, and also kept dry. It is now ready for the conversion process.

This is carried on in the dipping room, which is fitted with cast iron dipping troughs, located in a tank of running water, proper cooling troughs, and acid reservoirs. The acid used is received already mixed, contained in iron drums of about 1200 pounds capacity. The mixture is, as nearly as possible, one part by weight of pure nitric acid of 1.5 specific gravity to three parts by weight of pure sulphuric acid of 1.85 specific gravity, and costs 3¼ cents a pound. As in the converting and the two succeeding steps of the purification process a great deal of acid fume is liberated, the dipping and two following pieces of apparatus are connected with a fan, to take it up and drive it out. The prepared cotton is brought to the dipping room on the railway running through the factory. The dipper fills the troughs with acid and arranges his tools for use. The helper weighs out a pound of dry cotton, with which he

approaches the dipper, and pitching about a third of it into the acid, the latter submerges it with a steel fork, made for the purpose, and so on, until the first trough is charged with the pound of cotton. The other three troughs are similarly charged. When about ten minutes have elapsed, the dipper returns to the first trough, and with the fork gathers the gun-cotton out of the acid and puts it on a grating at its further end, and there squeezes the surplus acid out with a hand-press. By the time this is done, the helper has placed a stone jar, into which the two place the gun-cotton from the first trough. The helper presses it down in the jar, puts a cover over, and sets it in a cooling trough. The dipper replenishes the acid, and the trough is charged with cotton as before, and so on, until the day's dipping, about 110 pounds, is finished. The jars are left in the cooling troughs overnight, so that their contents may thoroughly digest and there remain no unconverted particles of cotton.

From the cooling troughs, the gun-cotton is taken to a centrifugal wringer, two jars at a time, in which the acid is extracted and caught in a drum. This spent acid is sold to the acid manufacturers for three quarters of a cent a pound. Extracting it is a delicate operation, and great care must be taken that no oil or water finds its way into the wringer, for, if it does, the gun-cotton will be ignited, and, under such circumstances, it is very difficult to draw the line between a fire and an explosion.

The gun-cotton, having been approximately freed from acid, is taken to the immersing tub, in which washing out the free acid is begun. Immersing acid gun-cotton in water is dangerous, and must be carefully and intelligently done. In this tub revolves a paddle-wheel, over which is a hopper, that communicates with the wheel by a slot. The gun-cotton is brought from the wringer in a tray, and placed in the hopper, from which it is fed by separate handfuls, down the slot, upon the revolving wheel, and into the flowing water in the tub. If it is otherwise fed down to the wheel, so much heat is developed in that part at the edge of the water that it may ignite, and burn the contents of the hopper and do other damage.

The gun-cotton is taken out of the immersing tub and thoroughly washed in a centrifugal wringer, and then placed in a gun-cotton boiling tub. These tubs are similar to the cotton-boiling tubs, differing from them in having the steam enter through the top, going to the bottom, then through a coil, and out. The boiling space is insu-

lated from the metal pipes by perforated boxing. Live steam does not come into contact with the gun-cotton, nor does the metal of the steam pipe. In this tub it is boiled in fresh water and 10 pounds of carbonate of soda for eight hours. It is then drained and thoroughly washed in a centrifugal wringer, and boiled again for eight hours in fresh water, and again drained and washed as before.

After the second boiling and washing, it is taken to the pulping machine, which is similar to the machine used in paper mills for pulping paper stock. In this machine, which is suitably filled with water, it circulates between the knives until pulped to about the fineness of corn meal.

From the pulping machine it is drawn off into a poacher, which is a large oval tub provided with a paddle-wheel in the middle of one side, working just clear of a platform with inclined approaches. The pulp and a sufficient quantity of water being in the poacher, its paddle-wheel is made to revolve, which causes both pulp and water to circulate, and the latter to wash the former. After an hour's washing the paddle-wheel is stopped, upon which the gun-cotton settles to the bottom. The soiled wash-water is drawn off by means of a telescopic pipe at one end of the poacher. Fresh water is added, and the cleansing continued until the washing water ceases to become soiled. The gun-cotton is then supposed to be clean and without free acid.

A sample is taken from the bottom of the poacher and submitted to the solubility test, to determine what percentage of soluble gun-cotton it contains, which must be less than ten per cent. The lower orders of gun-cotton are soluble in a solution of one part alcohol and two parts ether, and by means of this solution the test is made. It is then submitted to the heat test, to determine whether any free acid remains. To make this test, small quantities of the sample, thoroughly dried, are placed in test tubes which are fitted in a hot water bath, carrying a suitable thermometer. The mouths of the test tubes are closed with corks, under which are suspended pieces of iodide starch paper, which has been very carefully prepared. The bath is heated to 150° Fah., and the gun-cotton must bear this temperature for not less than fifteen minutes without turning the test paper brown.

Having passed the tests, the next step is to prepare it for service use. To every poacher full of it there is added three pounds precipitated chalk, three pounds caustic soda, and three hundred gallons of lime water. So fortified with alkali, it is pumped into what

is called the stuff chest, a round tank with a vertical shaft, carrying feathers to keep the pulp agitated and mixed with the water.

The gun-cotton being in the stuff chest is drawn thence and moulded, or pressed into shape for compressing, which is accomplished by means of a hydraulic press arranged for the purpose. Knowing the size of the compressed block desired, it is determined by experiment how much of the pulp is necessary to produce it, increasing or decreasing the length of stroke of the press pistons, then the moulding is proceeded with. The standard gun-cotton block for naval use is 2.9 inches square and 2 inches high, to produce which the moulded block must be 2.8 inches square and 5½ inches high, moulding at a pressure of 100 pounds to the square inch.

From the moulding press the blocks are taken to the final press, which is one of Sellers hydraulic presses with an 18-inch ram. In the receiver of this press the moulded blocks are placed between two perforated steel plates, a traveling block is then hauled over and the pump started, which forces up the ram and the pistons on top of it, which act on the gun-cotton in the receiver. The naval service gun-cotton is compressed at three tons to the square inch, and leaves the press with from 12 to 16 per cent of moisture, which is increased to about 35 per cent before issue to the service. It goes into the service packed in the standard tin exercise torpedoes and tinned sheet iron service torpedoes, which are capable of being made water and air tight, and have the necessary fitments for filling, fuzing, and being attached to spars preparatory to explosion.

The public owes much to the various experimenters with gun-cotton, but owes most to Von Lenk and Abel. The former determined the facts that the strongest and best gun-cotton is secured from the purest and best raw materials, and that to make it safe, its free acid must be extracted. The latter discovered how to make it safe, and how to increase its explosive effect. He also realized its true sphere of usefulness.

The filaments of cotton in the natural state are hollow, and all the spinning, weaving, and other processes to which it is subjected in the manufacturing and commercial worlds fail to destroy these tubes, as they may be called. Their existence caused the failure of the early gun-cotton makers, because, upon dipping the cotton into acid, it permeated the hollows of the filaments, and no ordinary method of washing served to extract it. With free acid in gun-cotton it is a question of short time for decomposition to begin and explosion to follow.

Abel, by discovering the pulping process, enabled the gun-cotton to be thoroughly purified of free acid; as by pulping the filaments are broken up and the water is able to wash it out. Again, by fortifying the purified pulp with a percentage of alkali to neutralize the nitrous exhalations which all nitrated bodies give off, sooner or later, and then compressing this purified product, he presented to the military world the ideal explosive for its purposes.

It is extensively manufactured in England, by government as well as by private individuals. In Germany, Italy, Austria, and other countries it is manufactured by private parties. It is used by the military services of the whole world, and is constantly growing in favor. The Chinese and Japanese are taking steps to establish their own factories and thus free themselves from the European manufacturers.

The United States Government should to-day have a half million tons of it, contained in torpedo and mine cases, distributed along the Atlantic, Gulf, Pacific, and lake coast, and at central distribution points along that line. It should also have a well drilled and organized naval militia, prepared to lay them out properly and put the life of death into them for those who attack us.

In these days, when the Monroe doctrine is expounded to embrace islands 2000 miles and more from the continent; when interoceanic canals are to be controlled; and when it is the mode to twist the tails of the British and Spanish lions, to pull feathers from the Gallic cock and the eagles of Germany and Austria, it were well that many and rapid steps be taken to enable the country to maintain and prosecute a fight, if one should be developed. From the point of view of one to whom war means promotion, aggressive foreign policy might be very promising, other things being equal. Alas! other things are not equal; and while this country, in area, wealth, population, and latent defensive and offensive war strength, ranks among the highest of first-class nations, yet in its immediately available defensive and offensive power, upon the sudden declaration of war, it ranks little, if any, higher than Denmark. Modern guns, forts, ships, torpedoes, mines, and gun-cotton must be accumulated, and the fighting strength of the nation trained in their use.

Wet compressed gun-cotton is the safest high explosive yet produced. It can be readily and safely transported by any conveyance whatever. It is eminently convenient and safe to handle, store, and work with. It can be sawed, turned, cut, and bored easily and with

perfect safety; and the turnings, cuttings, and borings may be worked over, as may old, distorted, or obsolete shapes. It can be compressed in any shapes or sizes.

Dry compressed gun-cotton is safer in every way than gunpowder, and a very small percentage of the whole weight of any charge for explosive work need be dry.

In view of the daily accidents with the ordinary market high explosives, it is pertinent to ask what would happen if the work of lining our whole coast with mines and torpedoes charged therewith were attempted? Our defense would be as dangerous to ourselves as to our enemy. No man fights well who is afraid of his weapon.

The time has arrived for private enterprise to take hold of gun-cotton. The processes and machinery for its manufacture can be greatly simplified and improved, and its sphere of usefulness much increased. It is certain that the overweening common sense of our naval and military ordnance authorities will, in the near future, cause it to be adopted as the normal high explosive for Government use. Even now, reasonable inducement might be received for private parties to move in the matter.

As superintendent of the factory whose processes this paper describes, I have, in the past three years, made many tons of it, handling it under various circumstances, in both the wet and dry states, without injury to person or property.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

ELECTRICITY ON BOARD WARSHIPS.

By S. DANA GREENE, late Ensign, U. S. N.

In the annual number of the "General Information Series, No. VII," published by the Office of Naval Intelligence, appeared a most excellent article on the subject of "Electricity on Shipboard," by Lieutenant J. B. Murdock, U. S. Navy. While some of the ground that he covered must necessarily be gone over in this article, my idea is to enter more particularly into the details of the application of *electric motors* on board ship; showing where such applications can be made to advantage, and what particular types of motors are best suited for the different classes of work to be done.

LAYING OUT AND INSTALLATION OF PLANTS.

The importance of applying electricity to all of our vessels is now thoroughly appreciated by the Navy Department and by all naval officers who have given the subject any study. The office of "Naval Inspector of Electric Lighting" was established by the Bureau of Navigation over two years ago (in January, 1887), and its title should now be changed to the office of "Electrical Applications," since, in the near future, *lighting* will be but one of several uses to which electricity is put. While on this subject, it would seem appropriate to urge the importance of concentrating the control over *all* electrical appliances for ship use under one office. On shore, it is now a well established fact, proved by many disastrous failures, that an electrical plant of any kind whatever must be laid out systematically and progressively from the start, having in view the character of work to be done, distance to be covered, best arrangement of central station, etc. On shipboard, where every foot of room is valuable for

some purpose, it is particularly important, first, that *all* generators should be concentrated in one place; second, that the generators and the wiring of the ship should be laid out with a view to *all* the work to be done, including lighting, power transmission, signaling, gun firing, torpedo work, etc. At present, each bureau of the Navy Department seems to have control (to a certain extent at least) of the electrical apparatus to be used by the department under its control aboard ship. If this system is carried out, the chances are that each bureau will get what apparatus it pleases, regardless of other bureaux, with the result of having on every ship three or four (possibly more) types of machines, many useless spare parts, and the occupation of more room than is necessary to get far better results. If the complete electrical installation of the ship is under one bureau, or office, whatever it may be called, then all of the practical information gained by former experience can be collected here; one man with proper assistance can lay out an installation with an intelligent knowledge of all the work that has got to be done and how it can best be done, and the work of installation can be properly supervised as it progresses. With such a system, we obtain the advantages common to a central station for light and power distribution on shore. By having the prime power bunched at a common station, one set of attendants suffices for the care of the machinery, one coal pile furnishes all the power, and where electric light and power are distributed in a number of units, the power required at the station (that is, the number of generating machines necessary) is much less than when each locality where the light or power is used supplies its own power. This is due to the fact that all consumers never use their maximum light or power at the same time; and it has been found in practice that central stations can actually rent *more* power to consumers than they have *at* the station. It is through a careful consideration and study of these facts that the transmission of light and power on shore has become both practicable and profitable, and it is only by following the same principles on shipboard that success can be obtained.

What has been said concerning the necessity of having one head who shall design and install the electrical plant complete on board ship, applies with equal force to its proper care and maintenance in service. The ordering of officers to ships for special duty has always been looked upon with disfavor in our service. The time is rapidly approaching, however, when it will require about the whole time and service of one man to care for the electrical apparatus, high explo-

sives, torpedoes, search lights and signaling apparatus of a large vessel, and it seems eminently proper to bring the matter up for discussion at this time, in order that those who have the efficiency and reputation of the service at heart can take the proper steps to introduce successfully into the navy that new agency for transmitting power which is making such rapid strides in commercial life.

If officers will take the subject up on a broad and liberal basis, electricity will rapidly replace steam on board ship and at our navy-yards for many of the auxiliary purposes for which the latter is now used, and will replace it with a great saving in first cost, with a much greater practical success in operation, and with greater comfort and satisfaction to those who have to live on board ship.

If, then, we are really desirous of obtaining the benefits arising from the substitution of steam or hand power by electricity in the navy, the following plan should be adopted:

1. The designing and laying out of the complete electrical plant for a ship or navy-yard should be done at one time and place, and under ONE head. Whether this head should be under one of the existing bureaux of the Navy Department, or whether he should have charge of a separate office, responsible only to the head of the Navy Department for his work, is a question which must be decided by those in authority, but it is a question which should be decided before the plants for all of our new vessels are required.

2. While a plant is being installed and when it is put into operation, ONE man should have charge of all electrical appliances, and he alone should be responsible for their proper care and maintenance.

THE ENGINES AND DYNAMOS.

In considering a combined light and power plant on board ship, the electric generators and their driving engines must be studied. The experience of the past five or six years in ship lighting has placed in the hands of the Navy Department so much valuable information concerning electric plants for ships, their practical working, their defects, and the requirements which the service imposes, that the specifications for plants to be used on the new cruisers can be drawn up minutely and accurately, and it can be safely assumed that the various electrical companies in the United States can successfully fulfill all the conditions imposed. Briefly, the dynamo room must be considered as one of the vitals of the ship (as are the engines, boilers, and magazines), and as such should be as thoroughly pro-

tected as the type of ship permits. The plant should possess compactness, lightness, strength, simplicity of construction, *absolute* interchangeability of parts, and, finally, economy. The experience gained in this country and abroad seems to point to the use of compound, condensing, high speed engines, coupled direct to low speed, multipolar, compound wound dynamos of high efficiency and constant potential. The plant should consist of two or more engines and dynamos. The engines as well as the dynamos should be duplicates of each other, and should be sufficient to operate the *maximum* number of lights and motors that would be used *at any one time*. As the load varies during the day, dynamos can be shut down or started up as required. The total output of dynamos need not be the sum of all the horse-power represented by the motors and lights in question. Central station experience on shore has demonstrated the fact that when there are many motors operating from the same station, only about 33 per cent of the power represented by these motors in the aggregate is *actually required at the station* to operate them. This is due, of course, to the fact that the motors are never exerting their maximum power at the same time. The same thing will be true to a certain extent in the case of motors on board ship, and it would seem unnecessary to allow for the dynamo capacity more than 60 per cent or 75 per cent of the total maximum power represented by those motors that will be in use at any one time, plus the lights required at the same time. Economy in coal consumed, for a plant of the size necessary for our large ships, dictates the use of compound engines; and the ability to operate incandescent lights, search lights, and motors from the same circuit would seem to indicate the desirability of compound wound dynamos. As before stated, these points were discussed very fully and clearly in Lieutenant Murdock's article.

The voltage used should not be less than 80 volts if motors are to be used on the circuits. The lower the voltage the greater the current used by a motor of given horse-power (since horse-power is measured by the product of volts and amperes). In practice it is found undesirable to go below about 80 volts for motors of any size; the large current requiring large wire on the motor and a large amount of copper in commutators, brushes, etc., to prevent undue heating. The requirements of engines and dynamos for ship work are necessarily much more rigid and severe than those imposed on similar machinery ashore; at the same time, special conditions should not

be needlessly imposed when the ordinary *commercial* requirements of an engine or dynamo will suffice aboard ship. A case in point occurred some time since. A special dynamo had been built for one of our men-of-war by one of the largest electric companies in the country. One condition imposed was that the field magnet coils of the dynamo should not rise more than a certain number of degrees in temperature under full load. The condition was very much more severe than that imposed by the company on their commercial machines. On the test the dynamo fulfilled the required conditions of load efficiency, non-sparking, etc., admirably, but the field coils slightly exceeded the limit in temperature. The dynamo was rejected, and being a special machine, it was virtually thrown on the company's hand. The dynamo would have done its work well, and the question of 4° or 5° Fahrenheit in the temperature of the field coils would never have been thought of again. Such a thing is naturally discouraging to a company when it is trying to aid the navy in creating a new type of machine to meet new and severe conditions, and it would certainly seem that the officer in charge of the government work should have some discretion allowed him in deciding on such a case. In order for a plant to be a success aboard ship the government officers and the manufacturers should work in harmony, each trying to give the other the benefit of experience obtained in previous work of a similar character. Hard and fast requirements cannot always be rigidly adhered to in a piece of machinery which has never existed before, and our officers should aid the efforts of the manufacturers whenever they can do so consistently with their duty to the government.

WIRING.

Too much care cannot be taken in this important branch of an installation. Upon it depends largely the success of the plant. Practical experience has shown the severe conditions that ship wiring imposes, and they can now be successfully met. The question of covering insulated wires with lead to protect them from mechanical injury or the deleterious influences of salt water, heat, and gases is one that should be thoroughly discussed. I very much doubt its value. On board the Atlanta the lead covering gave more trouble than almost anything else; in handling the wire the lead covering is almost sure to be more or less broken and bruised. A sharp point of lead will be forced into the insulation of the wire, sometimes touching the copper even, and a leak or even a short circuit between

the positive and negative wires is the result, since the lead covering is in contact with the steel bulkheads, etc., more or less. For the first six months after the ship went into commission, two or three men were kept constantly employed in removing sections of this wire and putting in new sections *without* the lead covering. In the engine and boiler room, and especially over the boilers, the insulation on the wire deteriorated very rapidly inside the lead covering, leaks and short circuits being the result. If the insulated wire needs a mechanical protection, it would seem that an armoring such as is used on submarine cables would be better than the lead covering. The following plan for laying out the wiring of a ship is suggested by experience on shore:

The mains to run fore and aft under the armor deck, and as much below the water-line as possible. There should be several parallel mains connected at intervals by cross branches to provide for possible accidents to one or more. The mains to be armored insulated cables run through tubes, or better, to consist of the regular underground tubes used so largely in many of our large cities to-day. They consist of bare copper wires or rods embedded in an insulating compound in the tube, the compound being run into the tube when liquid and allowed to harden. The tubes are joined together by water-tight junction boxes provided with screw plugs, which can be used for connecting on branch lines. The mains should be run while the ship is building.

Branch circuits running to the upper decks in each compartment should be run vertically wherever possible. A new system of house wiring has recently been developed which could be well applied to branch circuits. While a house is building, a series of flexible tubes of a tough insulating material are run behind the walls and ceilings. When the wiring is to be done, darts, carrying light strings, are blown through these tubes, and the wires are then hauled through the tubes by means of the strings. The tubes being flexible, the wires are not hauled around sharp corners or bends, and they are thoroughly protected from water or gases.

For the engine and boiler rooms circuits, the same arrangement could be used, or what would perhaps be better, run the wires *bare* in continuous porcelain or slate troughs. There is then no insulation to be affected by heat, the wires can always be seen, there could be no danger to the men with only 80 volts pressure, and the porcelain or slate would form an admirable insulation from the steel hull and bulkheads.

All cut-out and junction boxes should be water-tight and as accessible as possible. About the upper decks, where water is liable to get at the wires, they should be run either in continuous water-tight tubes, or else be left in plain sight in porcelain troughs, so that they can readily be inspected or repaired.

THE LAMPS.

The incandescent lamp is too familiar to need much mention. For ship use it would seem advisable to have as few sizes of lamps as possible. The saving effected by substituting a few 8 or 10 C. P. lamps for 16 C. P. lamps in certain places is very small, while the carrying of two or three sizes in stock means a good deal of unnecessary work in keeping them properly located and in keeping their various records. Ship lamps should have a short filament, on account of the danger of its breaking through vibration. Lamps should also be placed vertically rather than horizontally, for the same reason. The number of search lights on board ship will be constantly increased, probably, on our larger vessels, and attention should be paid to improvement of the regulation and feed of these lights. With the type of light in use on board the Boston and Atlanta, one man is kept pretty busy attending to the regulation of the arc and the feed of the carbons. It would certainly seem desirable to have some automatic device introduced to relieve a man of this work. Such a device would tend to steady the arc, and reduce or do away with the necessity of inserting a resistance in the search light circuit to steady the fluctuations and not affect the incandescent lamps.

MOTORS.

We now come to that application of electricity with which I am directly connected, and which I think gives such promise of successful introduction on board ship. I refer to the *transmission of power* by electricity. Probably no industry or business developed even in this progressive age has made such remarkable strides as the transmission and sale of electric power for commercial uses. Five years ago there was hardly an electric motor in use in the United States. To-day the single company with which I am connected has in use no less than 1200 *stationary* motors, aggregating over 5000 horse-power, and representing no less than 130 or 140 commercial industries; besides these stationary motors, we are now operating or building nearly 50 electrical street car lines, representing 200 miles

of road and 300 cars; we are equipping a coal mine with motors to be used for tram work, drilling and coal cutting; and we expect shortly to put in a 400 horse-power plant in one of the largest copper mines in the world. We are running whole mills entirely by motors; we are running dredges, incline hoists, and elevators, ventilating fans, ice cream freezers, and printing presses; last, but not least, we have recently finished a shell hoist for the U. S. S. Atlanta, and our men are now fitting a training motor and an elevating motor to an 8-inch carriage of the Chicago. I say this merely to show to what extent the electric motor has already replaced steam, water, gas, heat, and other forms of engines for general commercial purposes, and that it is destined to still further supplant them is proven conclusively by the number of companies springing up all over this country whose sole business is electric power transmission. Mr. Sprague, with whom I have the honor of being associated, in an elaborate and interesting paper read before this Institute two years ago, described the theory of the electric motor, and the reasons why the transmission of power by electricity is so much cheaper and more efficient than by any other method. I do not intend to go into the theory of the subject, but rather to try and show how and why electric motors can be advantageously substituted aboard ship for many of the auxiliary steam and hydraulic motors with which our new ships are crowded. First, let me state briefly the two general classes into which successful electric transmission may be divided.

1. Where large units of power are transmitted over long distances (varying from 5 to 25 miles), and where the work to be done is concentrated in two or three units.

2. Where smaller units of power are transmitted over comparatively short distances for a large variety of purposes.

Ship work comes under the second class, and is by far the most common and widely used method of transmission. It is the system now used in all of our large cities, where central stations for the distribution of lights have already been established, and where the revenue to these stations from their *sale of power* is rapidly approaching and will soon surpass that derived from the sale of *light*. Independent power stations are also being established, stations where nothing but power will be sold. These facts are sufficient to prove that the electric motor has passed the experimental stage, and that its superior reliability, economy and efficiency are an established fact. Both the army and the navy are conservative

where innovations or new devices are concerned, and properly so. The officers are charged with the expenditure of government moneys, and they have neither the authority nor desire to develop new commercial enterprises. It is *their* duty to take advantage of these new enterprises when they have proven themselves successful and when they can be applied with advantage to either service. A bill was before Congress at its last session to appropriate a generous sum of money for the development of the electric motor for naval uses, and it is to be hoped that this action of Congress will receive the cordial approval and support of all naval officers.

The work required of the auxiliary engines of one of our latest type of vessels may now be divided as follows:

1. Steam air and condenser pumps located in engine room, both for main and auxiliary condensers.
2. Steam pumps for fire purposes, for pumping out the ship, washing decks, etc.
3. Steam reversing engines for each engine.
4. Steam engine for jacking the engines.
5. Steam steering engine.
6. Steam capstan engines.
7. Blower engines for producing forced draught in the fire room.
8. Ventilating engines for ventilating the living spaces below.
9. Hoisting engines. Under this head are included steam ash hoists and hydraulic ammunition hoists.
10. Steam winches about the decks for lifting heavy weights, swinging out boats, etc.
11. Steam or hydraulic training engines for large guns.
12. Steam engines for driving the dynamos.
13. Steam engines for working lathes, drills, etc., in workshops.

Taken together, these auxiliaries will aggregate forty or fifty engines on a large ship, representing perhaps 200 H. P.

The engines, however, are never exerting their maximum power at the same time; hence if the work were done by motors, not over 60 to 70 per cent of this 200 H. P. (allowing liberally) would have to be provided for in the dynamo room.

Now I hold that the electric motor can replace every one of these auxiliary engines, and do so with a great saving in first cost and space occupied, and make the whole system of supplying auxiliary power cheaper, more efficient, simpler, and generally more satisfactory to every one.

It will be seen at a glance that it is necessary to distribute steam to every one of these auxiliary engines. Even the hydraulic machinery, very complex in itself, must have a steam engine to operate the compressing pumps. The engines are scattered all over the ship, from the capstan engine in the forward compartment to the steam steerer in the after compartment. To each engine it is necessary to run a separate steam and exhaust pipe. These pipes, varying from 3 inches to 5 inches in diameter, must pass through water-tight bulkheads, at each one of which a water-tight packing joint must be made; they must bend and twist and turn so as to take up as little room as possible, out of harm's way; they must be heavily lagged wherever they pass through officers' or men's quarters; finally, expansion joints must be provided between rigid bulkheads, or there will be constant leaks at all joints and flanges or else buckling of the pipes. On board the Atlanta, for the first year after the ship went into commission, a gang of men were kept busy repairing leaks and breaks in the steam piping. On a ship like the Maine or Texas, the piping for the auxiliary engines will run up into the *miles*. The first cost of laying the pipe is enormous; it requires constant attention to keep it in good condition, and even when in good condition, the pipes are hot and cumbersome and the engine dirty and noisy. If repairs are to be made to engines, they must be made by a machinist; a machinist is necessary to operate the engines. If a steam pipe should be struck by a shot in action (and it would be a hard matter *not* to strike one), there would be a rush of steam at 80 or 90 pounds pressure within the compartment where the shot entered, which would probably seriously injure or demoralize the men in that neighborhood. The engine connected to that pipe (and it might be the steam steerer) would probably be useless during the rest of the fight.

As to the efficiency of these auxiliary engines, it is probably very low, taking into consideration the fact that there is necessarily much loss in the pipes from radiation, condensation, and back pressure, and that small, simple engines of the type necessarily used are notoriously wasteful of steam and uneconomical in operation.

The mechanical applications made necessary by the use of auxiliary steam engines deserve notice. The steering engine is located at the stern of the ship, where it can operate directly on the tiller. The steering of the ship must, for obvious reasons, be done from forward. The usual method of operating the valve of the steam steerer from

the pilot house is to run a line of shafting from one point to the other; the shafting being operated either by hand or by another engine in or under the pilot house. On board the Atlanta this shafting passed along overhead on the gun deck, thence down to the berth deck and through the ward room, until it finally reached the steering engine. In this distance it made no less than *eight* changes of direction, necessitating *sixteen* bevel gears, besides clutch couplings for each of the three wheels. A 1-pound Hotchkiss shot coming in on the gun deck would knock the shafting out of line in a second, and the ship would then have to be steered by word of command passed along from the conning tower to the steering compartment. Another example of the cumbersome mechanical devices made necessary by the use of steam is the gun training engine for the 8-inch B. L. R. The engine for it took up so much room that it could not be put on the gun carriage. It was therefore put in a *room by itself* on the orlop deck, and connection was made to the carriage by a vertical shaft running up through *two decks*. The amount of power lost in friction and change of direction is great, and the executive officer's room was spoiled by having an ugly shaft running down through it. I mention these particular cases not to criticise the devices in themselves, but to show the non-adaptability of any system for ship use which makes such devices necessary.

Now, in what respects will the application of electricity be an improvement over the present system? Instead of the steam and exhaust pipes, 4 inches or 5 inches in diameter, being run all over the ship, we have in the first place our main conductors, running fore and aft, and secure below the water-line from shot and shell. The mains are perhaps one-half an inch in diameter instead of four inches. In each compartment where a motor is located, vertical branch lines are run to the motors and lights. These wires can be bent around corners or taken over or around obstructions at will. They require no elaborate water-tight slip joints at bulkheads; a half-inch hole with a small stuffing gland inserted is all that is needed. They require no lagging to make living quarters inhabitable; no expansion joints to prevent buckling of the bulkheads or leaks in the wires. The branch lines being run vertically, to a certain extent at least, present a minimum target to an enemy's shot. If a wire is shot in two, there is nothing to damage the men or create a panic among them; the most ignorant man aboard ship by a single twist can splice the break in a few seconds and the motor will run as well as it did before. In fact,

nearly every objection raised to steam pipes is eliminated. When we come to the motors, the advantages are equally marked. For equal horse-powers the electric motor occupies less than half the space of the steam engine and weighs less. There is no heat or escaping steam about the motor. Any "idler" can operate it by opening or closing a switch; and beyond an occasional filling of self-oiling bearings and cleaning of the commutator, the motor runs itself. The motion is *rotary* instead of reciprocating, which means invariably much more quiet operation, less wear and tear of parts, and simpler mechanical applications. These are the advantages possessed by the electric motor that have led to its extended application on shore in place of steam. They are the same advantages which will be obtained by its use on board ship. Two questions which are commonly raised about motors on shore by persons unacquainted with them will doubtless be raised by some officers in the service. They are, first, can motors be made of sufficient size to do the work required of them? and second, can they be relied upon to do the work as well and with as few breakdowns as the steam engine? The first question can readily be answered by simply stating that the regular *standard sizes* of the motors made by the Sprague Company range from one-sixteenth of a horse-power to *eighty* horse-power, the list comprising forty or fifty types of machinery. In every case the rated horse-power is that *delivered from the pulley* of the motor. On all motors above five horse-power in size, the commercial efficiency (that is, the ratio $\frac{\text{H. P. given out by motor)}}{\text{H. P. absorbed by motor)}}$ ranges from 80 to 90 per cent.

The second question is best answered by a reference to the commercial world, where hundreds of these motors, of all sizes and types, are running 8, 10 and 12 hours a day, every day in the year, and on which the repair account in many instances does not amount to $10 for the year. It is in this direction that the greatest advance has been made in motors during the past three or four years. When they were first introduced, troubles with the field coils, "crossed" or "burnt out" armatures, and commutators all cut to pieces by sparking and improper construction, were not of unfrequent occurrence. To-day such a mishap is extremely rare. Formerly, a motor was generally considered as a delicate piece of mechanism which must be kept under a glass case and labeled "handle with care." To-day we put a pair of motors under a street car, and run the car

through snow, slush, mud or rain, the car doing continuous duty for 16 or 18 hours out of the 24, and averaging from 90 to 120 miles per day. These facts speak for themselves. No service aboard ship can approach that required of a motor for street car service, either in variation of speed or load, length of continuous duty, suddenness of shocks, strains and jars, unfavorable conditions of weather, streets, inaccessibility and narrowness of the space allowed, and lack of even a small amount of attention. If we have a motor which is to-day successfully meeting and overcoming such conditions, is it unreasonable to predict that the same motor on board ship, where every condition is vastly in its favor, will do as well and better? The street-car motors are put under a car within six inches of the ground, and the car is operated by an ignorant man who cannot even see his motors, who cares nothing about them, and who cannot tell one end of it from the other. These motors run, not by reason of any fostering care on the part of the motor man, but *in spite of him.*

Salt water has always been regarded as a hated enemy of the electric motor or dynamo, until within the past few months; its omnipresence aboard ship would have been a serious objection to its use in many places. The same objection, however, had to be met and overcome in the street-car motor, and to-day we can actually soak an armature in a barrel of salt water, take it out, put it in a motor and run it. This is no idle boast, but a feat which has been actually accomplished. For some months the Sprague Company have been engaged in experimenting on a method of treating field coils and armatures with an insulating compound in such a manner as to render them impervious to water or acids. Recently an armature which had been put through the process was soaked for 24 hours in hydrant water. It was then taken out, measured, found to be sound in every respect, and then put into a barrel of *salt water* for 24 hours. At the expiration of this time it was taken out, put *at once* into a motor without a drying of any kind, and the motor was run for two hours on an overload varying from 25 to 50 per cent above normal full load. No test could be more thorough or convincing, none more satisfactory to us. In future, all of our motors subjected to the influences of the weather or to any unusually unfavorable conditions will be subjected to this process.

The class of work to be done by motors aboard ship may be divided generally as follows:

First Class.—Where the load varies, but speed of motor is con-

stant—running lathes or drill presses, for example. For this work a differently wound, constant speed motor is most suitable. Such machines do not vary more than 2 per cent in their speed from no load to full load. In some cases, where constancy of speed is not required within 5 or 10 per cent, a simple shunt machine will suffice.

Second Class.—Where it is desired to vary the load and speed only through a limited range—running ventilating fans, hoisting, and some pumping, for example. Here a cumulatively wound motor is desirable. In this case the field coil, in series with the armature, acts *with* the shunt coil in its magnetizing effect instead of against it, and a variation of from 15 to 30 per cent in the speed can be obtained.

Third Class.—Where the load and speed vary widely, but where the motor is never without *some* load, as, for example, in steering, gun training, and certain pumping. Here a plain series motor is the most suitable. The torque or turning moment of a motor varies directly as the product of the ampere turns in the fields and in the armature; in a series motor the same current passes through fields and armature; hence the torque varies as the *square* of the *current*. This means that in starting under a heavy load, or in moving the load slowly, a series-wound motor is capable of exerting an enormous torque for a short length of time.

These four types of motors will cover every class of work that an auxiliary engine on board ship can be called upon to perform, and the motor will do it better in every instance than the steam engine. The electric motor, as compared with the steam motor, is much more compact and lighter; simpler in construction, application and operating; less noisy, cleaner, requires no skilled labor to operate it; is more reliable, more efficient, and *less* likely to get out of order. Every one of these points are points in its favor for ship use. Suppose the Atlanta had an electric motor instead of the steam steering engine she has (which, by the way, takes up a whole compartment and makes the after part of the ward room uncomfortably warm and noisy when in use). The motor would occupy about *one fourth* the space, the steam and exhaust pipes would be replaced by the mains below the armored deck, and instead of the long line of shafting running from pilot house to engine, a small controlling wire would run down from the conning tower through a small armored tube, and thence aft under the armored deck to the controlling switch of the motor. What a saving in first cost of installation, simplicity and ease of operation, and safety in time of action! Suppose the 8-inch gun-

training engine, occupying a room by itself on the orlop deck, was replaced by such a motor as the Chicago will have. The motor will be placed between the side brackets of the lower carriage and under the breech of the gun. It will be so geared that by throwing a single clutch, either the motor or the hand-gear can be used. The long shafting running up through two decks is done away with, and the gun captain, with a simple lever in his hand, can train his gun with the greatest ease. I take pleasure in stating that the Sprague Company is now fitting such a motor (the first of its kind) to one of the 8-inch carriages of the Chicago. A smaller motor for elevating purposes is also being attached to the same carriage. At the same time, we have also put on board the Atlanta an ammunition hoist motor to be used in whipping up the 6-inch and 8-inch shell, and having attached to it a very ingenious hand control. The same hoist can be used for hoisting ashes or for any general hoisting. A power hoist is only advantageously substituted for hand hoisting where weights lifted are comparatively heavy (100 pounds or more), and where it is desired to handle them quickly, with a lift of say 25 feet or more. The principle of the floating lever as applied to steam ash hoists is well understood. Briefly, the man handling the hoist must keep a small crank or wheel in motion in order to keep the engine moving. If he stops turning the wheel, the engine stops. If he reverses the wheel, the engine reverses. This control of the hoist becomes very important in hoisting loaded shell, powder or high explosives. If a man is shot while hoisting, or if he becomes demoralized and lets go his hand wheel or ceases to turn it, the engine must stop at once; otherwise, the shell might be detached from the whip and dropped down to the shell room.

The new hand control carries out this principle fully. A man must turn a wheel in a certain direction to start the motor, and the speed increases as he increases the speed of rotation of his wheel. If he lets go the wheel, the motor is stopped. If he reverses it, the motor reverses. In testing the apparatus, it was at first found that when the current was cut off from the motor, the momentum of the armature carried it around for several revolutions, so that the weight being lifted or lowered was not brought to rest promptly. To remedy this, a magnetic brake has been applied to the armature shaft; the magnet coils of the brake (of very low resistance) are in series with the armature, and so long as a current is passing through the motor, the magnets are energized and the brake shoes are held away from

the shaft. When the current is shut off, a heavy spiral spring at once draws the brake shoes together and the armature is stopped.

These first two applications of motors on board ship, the Chicago's gun-carriage motors and the Atlanta's shell-hoist, will doubtless receive much criticism in the service. Every new piece of mechanism does, and it is right and proper that they should receive such criticism, since naval officers know best what are the requirements and conditions on board ship. It is only fair, however, that a new device should receive a full and thorough trial, and that when a criticism is made, there is a corresponding desire to improve. We already see where certain parts about the shot-hoist can be improved upon in any future orders, tending to simplify it and decrease the space occupied. It is the universal experience with all mechanical appliances, that successive improvements in them always mean a reduction in number of parts and simplifying of motions.

The chief object aimed at in applying the training and elevating motors to the 8-inch gun-carriage is to increase the speed of moving the gun, and to enable the gun captain to follow the object aimed at nearly or quite as readily as is now done with the Hotchkiss single-shot gun. A single universal movement lever controls both motors. The gun captain trains right or left by moving lever to right or left; if he wishes to raise or lower the breech, he raises or lowers the lever. A combined motion of the lever will produce a combined motion of training and elevating or depressing. It would seem that with such a simple and complete control of his gun, a gun captain will be able to follow his target with almost, if not quite, the ease that he does with a 6-pounder Hotchkiss, since the motion of the gun is coincident with the motion of the man's hand, both in direction and in speed.

The application of a motor for steering purposes deserves special mention. It has been suggested to have a motor to operate the *valve* of the steam steerer only. While this would do away with the clumsy mechanical devices now necessary to transmit motion from the hand wheel to the engine, it is only a step in the right direction. The moving of the *tiller itself* should be accomplished by a motor. The system would then be a completed whole, and there would be a large saving in space, weight, noise, and heat. The same hand control, already mentioned in connection with the shell-hoist, would be most suitable for steering purposes. The motor moving the tiller follows the motion of the wheel in the hands of the helmsman, both in direction and speed. If he stops turning his wheel, the tiller stops

in whatever position it may then occupy. This is analogous to the motion of the present steam steering engine. A pointer on the standard supporting the wheel indicates at any time the position of the tiller. It will be of interest to naval officers to know that the methods above described for adapting the electric motor to the handling of guns, steering and hoisting, are themselves the design of a naval officer, Lieutenant Bradley A. Fiske.

It will be seen from the foregoing remarks, that in introducing the motor on board ship, the navy will simply be following the experience and practice of commercial life, and there can be no reasonable doubt that the same advantages which have followed the introduction of the motor on shore will follow with even greater force its introduction on shipboard.

ELECTRIC RANGE FINDER.

One of the latest applications of electricity to nautical and military purposes is the range finder, also invented by Lieutenant Fiske. It is impossible at present to obtain the details of the apparatus, but it is known to consist of an electrical device by means of which the exact position of two telescopes at the ends of a base line of known length is automatically given. As applied to the Chicago and the Boston, the Bureau of Ordnance has insisted that the range finder shall give accurate indications of the distance of objects on any and all bearings, and that it shall not interfere in any way with the working of the ship or any part of its armament or equipment. It is expected that this invention will increase the ease and value of fleet evolutions, since every ship will have absolute knowledge of her distance from the others; and that it will lessen the dangers of coasting, since a vessel can plot her exact position as often as desired, having the means at hand for ascertaining both her distance and her bearing from any landmark, buoy, or lightship within sight. As an example of the accuracy of the instrument, it may be stated that the average error of twenty observations, half by night and half by day, was less than one per cent, the ranges varying from 500 yards to 2600 yards, the instrument being the first one constructed and necessarily crude.

SIGNALING BY ELECTRICITY.

One of the most serious problems to confront the commander-in-chief of a modern fleet or squadron is the transmission of signals in time of action to the vessels under his command. The enormous

powder charges used in all modern high power guns create such a smoke after the first round is fired that signaling by flags, semaphores, etc., is out of the question. It has been suggested that it is a perfectly feasible plan to communicate between vessels by means of electricity, either by induction or by the direct action of an electric current. Two years ago, while attached to the Atlanta, I assisted Lieutenant Fiske in some interesting experiments of this nature. While the results obtained were not as successful in point of distance as we had expected, we did transmit signals from the Atlanta, then lying at the dock (New York Navy-yard), to the tug Nina, stationed in the Wallabout, there being no wire connection of any kind between the two vessels. The man receiving the signals had a pair of telephones at his ears, and the make and break of an ordinary telegraph key in circuit with the Atlanta's dynamo was distinctly heard. The results obtained would, at least, seem to warrant further experimenting in the same direction. A man receiving such messages by telephone could be stationed on the orlop or berth deck by himself, where he could be quiet, and he could then transmit them by speaking tube or telephone to the commanding officer.

Night signaling is now extensively done by electricity. The incandescent light offers a ready substitute for the torch or signal lantern in signaling between vessels that are within sight of one another. Devices for signaling by the incandescent lamp have already been devised and described. The search lights, however, offer a much more comprehensive system of signaling. Their powerful beam of light, when thrown into the sky, can be seen 20 or 30 miles away, and by having a quick-moving shutter or screen to cut off the light, the regular Morse code can readily be used in transmitting signals. Vessels separated by high land have thus communicated with each other and with forces on shore.

ELECTRIC ANNUNCIATORS, BELLS, GUN-FIRING CIRCUITS, ETC.

Electric communicators, bells, etc., have now reached such perfection and are so familiar to all that they need no description. They are largely used on all of our new vessels. The firing of the heavy guns by electricity, however, is a matter that should receive careful attention. Some experiments have already been made on board our older vessels, and new designs have been prepared for the Bureau of Ordnance for our new vessels which embody many improvements over the old system. While it may be true that the guns will ordi-

narily be fired by the gun captains, the commanding officer may nevertheless want control of the battery at a critical moment, and *this* is the time when the firing circuit will come in. It would certainly seem that the comparatively small outlay necessary for its installation would be well compensated for at such a time. Moreover, the gun captain himself should be able to fire his gun by electricity. An astronomer, when using a transit instrument, records the transit of the body observed on the chronograph by pressing an electric button. He uses electricity because he has got to *record* simultaneously with the transit of the body across the wires in the field of vision. Just so the gun captain should be able to press a key and fire his gun the *instant* his sights come on the object aimed at, and this can be accomplished by electricity better than by any other known method.

If electricity is to be introduced on board our war ships as generally as this paper contemplates, it is necessary that the navy co-operate heartily with the manufacturers in their endeavor to produce what is wanted, and I feel confident that all officers who have the best interests of the service at heart stand ready and willing to do so. The use of electricity means increased efficiency and economy in the operation of all auxiliary engines on board ship, and greater health and comfort for the officers and men.

[COPYRIGHTED.]

U. S. NAVAL INSTITUTE, NEWPORT BRANCH.

JULY, 1889.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XXI.

Several U. S. patents have been recently granted to James Weir Graydon for inventions which relate to the use of high explosives for war purposes. U. S. Patent No. 399882, March 19, 1889, is for "A Revolving Air-Gun" for throwing dynamite or other high explosive projectiles, the object of the invention being the production of a gun in which, by the simple turning of a crank, the projectiles may be automatically placed in the barrels, the barrels revolved, and the projectiles discharged under a predetermined regulated degree of air pressure.

U. S. Patent No. 399883, March 19, 1889, is for a "High Explosive Charge," which is to be made by soaking woolen or cotton cloth or like fabric in nitro-glycerine until saturated, and coating the whole with paraffined paper, which is cemented to the cloth, or with shellac or any coating which will prevent the exudation of the nitro-glycerine. The cloth may be in sheets or in ribbons, and the charges may be made up by rolling up the fabric into cylinders. When in ribbons, the charge may be made up by placing the tape-like disks on one another.

U. S. Patent No. 399881, March 19, 1889, is for a "Shell" for use with powder-guns. This shell is to be charged with the tape-like disks (described in the last mentioned patent) of "dynamite cloth," as

* As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. Address *Torpedo Station, Newport, R. I.*

the inventor calls it, the shell having been previously lined with finely pulverized niter placed between two layers of cloth or other suitable fabric, which are protected from the moisture of the atmosphere by shellac or other similar material. The niter is used because, while it will "prevent heat engendered by the explosion of the propelling charge in the gun from reaching the bursting charge," it will also, "when subjected to the very much higher degree of heat produced by the explosion of the bursting charge, be converted into a gas, thus adding to the force of said charge." The niter is stated to resist a temperature of over 600° F., but when subjected to a temperature of above 644° F. it evolves oxygen gas freely, and this gas, mingling with the gases produced by the high explosive, will render the latter very much more effective.

Besides this and other features there is a flexible porous sack cemented to the point of the shell, and this sack is filled with oil. When the shell moves, the air pressure forces the oil out so as to lubricate the gun and shell and reduce the friction.

U. S. Patent No. 399877, March 9, 1889, is for a "High-Explosive Shell" for air-guns, the object being to provide a projectile which can be readily loaded and unloaded, and in which the density of the bursting charge may be equalized throughout the length of the charge chamber. He seeks to secure this by means of a perforated metal tube which fits in the center of the shell and runs the entire length, and which has secured to its exterior surface and throughout its entire length a continuous spiral sheet-metal flange or vane, this vane being also perforated. The interior of the tube contains the fulminate charge, while the high-explosive charge is coiled between the spiral vanes.

This high-explosive charge is the subject of another application, Serial No. 287630, October 9, 1888, and it consists of a flexible tube of some absorbent material, such as cotton or linen, which is filled with the dynamite or other high explosive. It is stated that when the charge thus put up is required for use, it is preferable to saturate the tube with nitric acid in order to convert it also into an explosive. This form of explosive is designed both for torpedo and artillery purposes.

U. S. Patent No. 399876, March 19, 1889, is for a "Circuit-Closing Device for Electrical Torpedo Fuzes," the peculiarity of which resides in the fact that it is to be operated by the pressure of the water when the torpedo has reached a predetermined depth.

U. S. Letters Patent No. 401851, April 23, 1889, has been granted H. W. Parsons for a "Distributor for Explosive Bombs,"* which consists of a frame carrying the desired number of bombs, and which is so controlled by electricity that any desired number of the bombs can be released at any desired time. It is intended that the distributor shall be attached to a balloon or float suspended in mid-air and operated from the ground.

From a private communication we learn that the insensitive nitroglycerine employed by Mr. S. D. Smolianinoff in the experiments described in these Notes (*Proc. Nav. Inst.* **13**, 573; 1887) is now styled *Americanite.*

U. S. Letters Patent No. 396739, January 29, 1889, were granted G. C. Gillespie, of Brooklyn, N. Y., for a "Machine or Engine for the Application of Explosive Energy to Mechanical Power," in which he states that the primary object to be attained in the construction of any machine operated by the sudden generation of high-pressure gas—as, for example, when gun-cotton is exploded—is to provide a means of controlling the power at the outset, and thus preserve the apparatus from any destructive shock. This object he claims to accomplish by the use of a cylinder and plunger, both of which are movable instead of one being fixed, as in the case of ordinary steam or gas engines.

Another important point, he states, to be provided for is the prevention of overheating, and this he claims to accomplish by the use of single-action cylinders which are drawn completely away from the plungers at each downward stroke, thereby enabling the gaseous products of the explosion to escape freely, and thus exert a cooling effect by their expansion.

A lecture on "Recent Inventions in Gunpowder and other Explosives" was delivered on Friday, the 5th of April, 1889, at the Royal United Service Institution, by Mr. W. H. Deering, F. C. S., F. I. C., Chief Assistant Chemist to War Department. The author referred first to brown or cocoa powder,† which was introduced in Germany, in 1882, in the well known form of a hexagonal prism with a central cylindrical hole. Its composition differs widely from the black powders then in use, being 79 per cent potassium nitrate, 3 per cent sulphur, and 18 per cent of a very lightly baked brown charcoal.

* *Vide* Proc. Nav. Inst. 13, 412; 1887. † Ibid. 11, 283; 1885; 13, 658; 1887.

Prismatic brown powder, which is used in the larger English breech-loading guns, is of this composition, very slightly carbonized straw being used for the brown charcoal. For the same muzzle energy, this powder causes less pressure and less smoke than black gunpowder of the old composition. From investigations into the products of combustion in each case, it is found that in the brown powder there is present more of the oxidizing niter absolutely and relatively to the reducing charcoal and sulphur than in the black powder; thus the residue of the former is fully oxidized, and the gases contain only 7 per cent by volume of unoxidized or imperfectly oxidized constituents, while the residue of the black powder contains some 24 per cent of unoxidized constituents, and the gases 22 per cent. The volume of the gases produced in each case is about the same, but the temperature in the case of the brown is greater than in that of the black powder; hence it follows that the diminished pressures produced by the former must have been due to its slower rate of burning, which depends on its chemical composition.

Sir F. Abel and Captain A. Nobel have experimented with a mining powder, which is interesting as an example of the influence of a change of composition in the opposite direction to that of brown prismatic powder. Its ingredients are: niter, 61.92 per cent; sulphur, 15.06 per cent; charcoal, 21.41 per cent; and water, 1.61 per cent. The products of combustion are much richer in unoxidized products than those of the pebble powder, and the temperature is less. They have come to the conclusion that the gunpowder which gives most gas and least heat causes the least erosion in steel tubes. In view of this statement, it would be interesting to know how a powder of the composition of this mining powder, in the form of prisms of the usual shape and size, would behave as a gunpowder, and whether satisfactory ballistic results and less erosion would be obtained with it.

The lecturer next dealt with nitrate of ammonium gunpowder, and referred to the so-called amide powder* of Mr. F. Gaens, which has the following composition: 101 parts by weight of ordinary niter, 80 parts nitrate of ammonium, and 40 parts charcoal. It is claimed that in ignition, potassamine (KH_2N) is formed, which is volatile at high temperature and increases the useful effect of the explosive; that there is very little residue; that no injurious gases are generated, and that little smoke is produced. It is, however, open to question

* Proc. Nav. Inst. 13, 593; 1887.

whether the potassamine is really produced, or whether the products of combustion are not similar to those obtained from ordinary gunpowder. The powders referred to in Krupp's last report (No. 53, October, 1888) probably contain nitrate of ammonium, as may be deduced from the published accounts of their trial. Both those for small and large guns gave better results than the German service brown powder, and they were all very hygroscopic. A similar powder seems to have been used with the Swiss Hebler rifle. E. X. E. powder and S. B. C. powder were also mentioned as having been tried against English brown prismatic powder for heavy guns, with more or less satisfactory results. Perforated cake powders were mentioned as applications of the principles introduced by the American General Rodman in 1862, as also the efforts that have been made to obtain a charcoal of uniform chemical composition, either by the method of blending or by using uncharred turf or bog stuff.

Next, the interesting subject of smokeless powders* was reached. Within the last three or four years, several preparations which have been stated to give practically no smoke have been proposed as substitutes for the the old niter, sulphur and charcoal powders. They consist essentially of nitro-cotton or other kind of nitro-cellulose, specially treated with a view of producing a slower burning substance; or of nitro-glycerine and nitro-cotton. It was to be noted, however, that the presence of metallic nitrates would be incompatible with their smokelessness. This the lecturer exemplified by experiment. By the use of a suitable preparation of nitro-cellulose, or similar chemical compound, a practically smokeless powder is attainable, giving, with less weight of charge than ordinary gunpowder, very high velocity to the bullet, and making the cartridge of the small-bore rifle a little lighter. Vieille's powder (or "Poudre B"), which is used for the French Lebel rifle of 0.315-inch caliber, is stated to give to the bullet, which weighs 231 gr., a muzzle velocity of 1968 ft. sec., or, according to another statement, 2034 ft. sec., and to produce little or no smoke. Several patents have been taken out in England for various methods by which it is sought to slow down ordinary service gun-cotton (trinitro-cellulose) so that it can be used in a firearm without producing enormous initial pressures. Thus, in the Johnson-Borland powder the salient feature consists in forming nitro-cellulose into grains or prisms, which, after being dried, are saturated with a solution of camphor in a volatile solvent such as will evaporate below

*Proc. Nav. Inst. 13, 593 and 594; 1887; 14, 161, 438, 759-760; 1888; 15, 312; 1889.

100° C. This solvent is distilled off by a gentle heat and recovered, and the camphor is left in the solid state, intimately mixed with the nitro-cellulose. The material is then heated in a closed vessel, when the camphor exercises a remarkable gelatinizing effect on the nitro-cellulose, the hardness being regulated by the amount of camphor used, and not being merely on the surface, but extending throughout the mass. This peculiar property of camphor has long been utilized in the manufacture of celluloid. Engel, Glaser, and Turpin have also patented processes, and in all three the nitro-cellulose is dissolved or gelatinized in a solvent, by which treatment the fibrous character of the material is destroyed and a horny product obtained, burning in the rifle or gun at a slower rate than in the fibrous condition. Another powder of this class is that of Mr. A. Nobel, the founder of the nitro-glycerine industry. It is a horny preparation, composed of nitro-glycerine, nitro-cotton, and camphor. It is a kind of blasting gelatine, with the proportion of nitro-cotton greatly increased, and with the addition of camphor. The resulting product resembles celluloid in appearance, is easily formed into grains or pellets of any shape, and, it is claimed, burns in firearms slowly enough to render it a fit substitute for gunpowder, over which it is said to have the advantage of greater power, of leaving no residue, and of being practically smokeless. The permissible range of variation of the constituents is a wide one. Two examples of mixtures are given, representing the extremes of variation. In 100 parts by weight of nitro-glycerine, 10 parts of camphor are to be dissolved and 200 parts of benzol added. In this mixture, 50 parts of dry soluble nitro-cotton pulp are to be steeped. The benzol is then evaporated, and the material mixed by passing between rollers, which are hollow, and heated by steam to 50° C. or 60° C. When uniform, it is rolled out into sheets, and cut up into grains or moulded. Or, when it is required to reduce the amount of nitro-glycerine as far as practicable, 100 parts by weight of nitro-glycerine, 10 to 25 parts of camphor, and 200 to 400 parts of acetate of amyl are mixed, and 200 parts of dry soluble nitro-cotton pulp are steeped in the liquid. The material is then kneaded into a paste, the solvent is removed by heat, and the dry material cut up into grains, as before.

The lecturer concluded by referring to the picrates. After mentioning the powders of Abel and Turpin, he proceeded to say that picric acid is the predominating constituent of "mélinite,"* intro-

* Proc. Nav. Inst. 12, 616; 1886; 13, 581; 1887; 14, 151, 435 and 755; 1888.

duced into service use in France, in 1886–87, for charging shells. It is probable that ether is one of its constituents, its use being to cement together picric acid grains by means of collodion, a solution of dinitro-cotton in ether and alcohol. It is questionable whether the quantities of carbolic acid available for the manufacture of picric acid would be sufficient to meet large and continued demands for the latter. The available supplies of cotton for making gun-cotton, and even of glycerine for nitro-glycerine, are much less likely to be affected by a run upon them than those of carbolic acid, which depend upon the amount of coal tar produced, mainly in gas making. From French and German statements it appears that a vault of concrete 10 feet thick, not covered with earth, which would act as tamping to the explosive, may be considered as almost invulnerable to the attack of mélinite shells.

A short discussion followed the lecture. Mr. Nordenfelt said that it was not a question as to whether we should adopt a smokeless powder, but which smokeless powder should we adopt. Sir F. Abel pointed out the difficulties in selection, and the caution that is necessary; while the chairman wound up the discussion by reporting some extremely interesting ballistic results, transmitted to him from Elswick. It appears that the "velocity pressure curve" obtained there with the Chillworth special powder is almost ideal in its perfection. With the 4.7-inch gun, firing a 45-pound projectile, a muzzle velocity of 1990 ft. sec. was obtained with 13½ tons pressure. In our new rifle, the black pellet powder is to give a velocity of 1810 ft. sec. with 18 to 19 tons pressure; but with a powder known as the R. C. P., employed at Elswick, with the same pressure, a velocity of 2050 ft. sec. was reached.—(*Industries* **6**, 426–427; 1889.)

The valuable paper by Sir Frederick Abel and Colonel Maitland, on the "Erosion of Gun-barrels by Powder-products," which was published in the *Jour. Iron and Steel Inst.*, No. 2, 1886, has been reprinted in full in the *Notes on the Construction of Ordnance*, No. 46, published by the Ordnance Department, U. S. A.

English Patent 13656, September 21, 1888, has been granted C. F. Hengst for an "Improved Safety Smokeless Gunpowder," which is produced by nitrating pulped straw, and after removal of all traces of acid, granulating the product, with or without the addition of oxidizing agents.

English Patent 7608, May 25, 1887, has been granted Wohanka & Co. for "Improvements in the Manufacture of Explosives," which consist in adding cellulose to the liquid explosives, made by dissolving in concentrated nitric acid the nitro-derivatives of the hydrocarbons of the aromatic phenol series. The cellulose becomes nitrated and swells up, forming with the explosives a plastic mass resembling gelatin.

English Patent 18362, December 15, 1888, has been granted J. W. Skoglund for "Improvements in the Manufacture of Explosive Compounds," which invention relates to the manufacture of explosive compounds consisting of nitro-cellulose or trinitrophenol, together with the radical of carbonic, oxalic, or carbamic acids, in combination with ammonium or another volatile radical base or hydroxyl.

English Patent No. 5270, April 9, 1888, has been granted Le Vicomte Hilaire de Chardonnet for a "Process for Denitrating and Dyeing Pyroxilin," which consists in treating nitro-celluloses with nitric acid of a density of 1.32, whereby in a few hours they lose part of their nitrogen and become reduced below the state of the "tetranitrate," at the same time beginning to soften and being rendered more easy of treatment in dyeing and other operations.

English Patent 8253, June 8, 1887, has been granted F. Crane for "Improvements in Pyroxyline Compounds and Varnishes," in which propyl and butyl acetates alone, together, or mixed with benzene, light petroleum, acetone, methyl and ethyl alcohols, and amyl acetate, are used as solvents for pyroxyline for the manufacture of varnishes and lacquers and for the production of celluloid.

The advantages claimed for the propyl or butyl acetates are their good solvent powers, the sufficient but not too great rapidity with which they evaporate, their non-hygroscopic character, the ease with which they mix with the other substances mentioned above, and their comparatively agreeable odor.

English Patent 2694, February 21, 1887, was granted M. P. E. Gérard, Paris, for a composition capable of being formed into threads, films, sheets, slabs, or moulded articles, or used as a varnish, the composition of which is: Ten parts gun-cotton and five parts gelatin are separately dissolved in acetic acid, then mixed together. A small quantity of glycerine and castor oil, or in other cases a little gluten, glucose, or honey, is added to improve the com-

position. The addition of a trace of calcium chloride renders it uninflammable. The product can be used as a varnish for wood, etc., and especially for plaster, and can also be moulded into articles of great delicacy of structure.

English Patent 5824, April 21, 1887, has been granted J. W. Knight and W. D. Gall for "Improvements in the Manufacture of Carbolic Acid and other Tar Acids," by which the carbolic oil is treated with lime and agitated with a hot solution of sodium sulphate, the carbolate of lime first produced being converted into carbolate of soda, with simultaneous formation of calcium sulphate. The watery liquid containing carbolate of soda is drawn off and decomposed with sulphuric acid. The carbolic acid rising to the top is then separated from the lower liquid, which consists of a solution of sodium sulphate ready to use for another treatment with a fresh quantity of oil. The exhausted oil may be passed through filters in order to remove the calcium sulphate.

U. S. Letters Patent No. 403749, May 21, 1889, have been granted J. A. Halbmayr for a method of "Manufacturing Explosives" from tar-oils, which consists in conducting the oils into a body of nitrating acid from below the surface of the latter in a state of division, and at the same time introducing cold air under pressure at the same point with the oils. This is accomplished by using a series of tall water-jacketed tanks filled two thirds full of fuming nitric acid, and reservoirs for the tar-oils which are placed at higher levels than the converting tanks, so that the oils can by gravity be forced into the bottom of the converting tanks, cold air being introduced under pressure at the same point. The nitro-derivatives rise to the top of the liquids in the converting tanks, and by suitable overflow pipes they may be removed. By using a series of these converters at different levels, the operations may be repeated so as to ensure more complete and thorough conversion of the lower or the production of the higher nitro-derivatives.

The Favier Company, in Belgium, have recently brought out a new explosive which consists of a mixture of mononitronaphthalene and ammonium nitrate. The cartridges which are made with this explosive are made waterproof by dipping in molten paraffin. The composition of the cartridge core is as follows:

	Per cent.	Per cent.
Mononitronaphthalene (not quite pure, melting point from 51° to 56° C.),	8.15	7.97
Ammonium nitrate,	91.55	91.83
Insoluble in water and ether,	0.14	0.20

Or, if the covering of paraffin be included in the analysis, they test thus:

	Per cent.	Per cent.
Mononitronaphthalene,	7.77	6.86
Paraffin (melting point 56° C.),	4.04	4.41
Ammonium nitrate,	88.01	88.09
Insoluble in water and ether,	0.22	0.34

One molecule of nitronaphthalene requires, theoretically, 21½ molecules of ammonium nitrate in order to burn to carbonic acid, water and nitrogen. But if both the 4.41 per cent of paraffin and the 6.86 per cent of nitronaphthalene are oxidized completely, 144.62 per cent of ammonium nitrate is required, whereas the amount of ammonium nitrate present (88 per cent) is only sufficient to oxidize the carbon to carbonic oxide. Such an explosive is unsuitable for underground blasting. The new explosive is indifferent to concussion, and burns with difficulty. In order to cause it to explode, two grams of fulminate are required, but as this priming is about six times as expensive as the priming of a dynamite cartridge, it is questionable whether Favier's explosive can ever hope to compete with dynamite. Favier failed in obtaining a patent in Germany, nor has he been more successful in finding capitalists in that country inclined to work his "invention."—(*J. Soc. Ch. Ind.* **8**, 519; 1889; from *Chem. Ind.* **11**, 241.)

English Patent No. 8929, June 22, 1887, has been granted H. Güttler for an "Improvement in the Manufacture of Charcoal for Explosives and other Purposes, and Apparatus for that Purpose."* In the apparatus described, the material is suitably contained in an air-tight cylinder, which is fitted with a pressure gauge and pyrometer and heated by means of a muffle. The carbonization takes place in a current of heated carbon dioxide, and the pressure of the same in the cylinder can be varied at will. The temperature is regulated by admitting cold air to the muffle and by varying the supply of heated gas to the cylinder. After the charring is complete,

* Proc. Nav. Inst. 15, 314; 1889.

cold air is rapidly drawn through the muffle, and cooled carbon dioxide passed through the charcoal, which rapidly cools and absorbs the carbon dioxide in its pores. Charcoal treated in this manner is said to be proof against spontaneous ignition.

The *Jour. Soc. Chem. Ind.* **7**, 488–489; 1888, contains a detailed account of the visit of the society to Nobel's Dynamite Works, near Stevenson, Ayrshire, and of the experiments with dynamite and blasting gelatin which were made on this occasion. On pages 490–493 of the same journal is a paper on the "Manufacture of Explosives as carried on by Nobel's Explosives Company." Besides nitroglycerine, dynamite and blasting gelatin, this company manufacture detonators and fulminate of mercury. It was claimed that the Stevenson factory was the largest dynamite factory in the world, and produced about eight tons of explosives daily.

U. S. Letters Patent No. 397285, February 5, 1889, have been granted to G. E. F. Grüne for a method of "Preparing Dynamite," which consists in first mixing kieselguhr with sugar, starch, cellulose and like substances, or blood, glue, casein and the like, then compressing the mixture into cartridges, which are then carbonized so as to obtain an intimate mixture of carbon and kieselguhr. These cartridges are then immersed in nitroglycerine until saturated, whereby they are converted into dynamite. It is claimed that this dynamite is water-resisting, and that these cartridges may be kept and transported under water without producing any diminution in their explosive power.

U. S. Letters Patent No. 398559, February 26, 1889, have been granted to J. Waffen for a "Dynamite." In manufacturing this explosive he first makes a mixture of

Sodium nitrate,	22.50 parts.
Decayed wood (well dried),	36.00
Picric acid,	.25
Sulphur,	1.00
Sodium carbonate,	.25

Next he mixes together

Nitroglycerine,	94.00
Collodion,	6.00

and then he takes 60 parts of the first mixture and 40 parts of the

second and mixes the whole together until the mass presents the appearance of a uniformly fatty substance.

English Patent 758, January 18, 1886, has been granted W. D. Borland for "Improvements in Explosive Substances and Absorbent Materials therefor." It is stated that the most porous forms of charcoal at present known will not absorb more than from 5–6 times their weight of nitroglycerol, in consequence of which large proportion of charcoal in the explosive, the gases produced by explosion contain too much carbonic oxide. By this improved process, a carbonaceous material is prepared capable of absorbing as much as 35 times its weight of nitroglycerol. The inventor carbonizes small pieces of cork waste or any form of cork in a convenient and suitable manner. "When properly prepared the carbonaceous substance readily absorbs from 7–8 times its weight of nitroglycerol, giving a pulverulent mixture; from 10–12 times, giving a plastic-like mass; and is capable of absorbing even so much as from 30–35 times its weight, yielding a stiff paste of homogeneous appearance from which no nitroglycerol separates, even after many months' immersion in water."

The mixture of 7–8 parts of nitroglycerol with one of the carbonaceous material is excellent for cartridges, and may be safely moulded under water. Mixed with one-fourth its weight of water it becomes absolutely uninflammable, but may be detonated. A mixture of 75 parts of nitroglycerol, 3 parts of the carbonaceous substance, 2 of alkaline carbonate, and 20 of kieselguhr is extremely dry to the touch, less affected by freezing and thawing than ordinary kieselguhr dynamite, and may be immersed in water for an indefinite length of time without showing signs of exudation.

English Patent 3759, March 10, 1888, has been granted E. Kubin and A. Siersch for "Improvements in Explosives." "The object of this invention is to provide an explosive which, on being detonated, will prevent danger of ignition of fire-damp or coal-dust in mines."

For this purpose chloride or sulphate of ammonia, or the two salts together, are mixed with dynamite, blasting powder, or other explosive, in proportions varying from 20 to 50 per cent. On the detonation of the explosive the ammonia salts are decomposed into non-inflammable gases, which have the effect of reducing the temperature and rarefying the explosive gases.

At the commencement of 1888 "The Flameless Explosives Company, Limited," was started in London. The flameless powder* is the invention of Hermann Schöneweg, of Dudweiler, near Saarbrücken, Germany. His invention consists in surrounding a blasting cartridge with a casing containing oxalic acid or oxalates, with the addition of oxygen-carriers, for the purpose of extinguishing the flame of the fuze and increasing the explosive power of the cartridge. It is mentioned in the prospectus of the company, that if an equal amount of the Schöneweg mixture (consisting of 75 per cent of ammonium oxalate and 25 per cent of potassium nitrate) be added to dynamite, blasting gelatine, or similar substances, no flame is produced on explosion; but this assertion has not been sufficiently tested. Besides, dynamite requires a far larger amount of potassium nitrate and ammonium oxalate than has been added in order to burn to carbonic acid, water and nitrogen, and, in the absence of these oxidizing agents, a large quantity of carbonic oxide, ammonia, and perhaps hydrocyanic acid would be given off. For this reason the author does not anticipate a great future for the flameless powder. Schöneweg did not succeed in having a patent granted to him in Germany. He has also conferred the working of his securite patent to the company mentioned. Securite consists of dinitrobenzol and ammonium nitrate. The Royal Mining Inspector, Margraf, testifies in the prospectus of the company to its being absolutely safe in the presence of marsh-gas and coal-dust, whereas the experiments of the Royal Saxon mining authorities gave the very opposite result.—(*Jour. Soc. Ch. Ind.* **7**, 519; 1888.)

English Patent No. 5949, April 21, 1888, has been granted A. Kuhnt and R. Deissler for an "Improvement in Explosive Compounds," which consists in substituting for the water-cartridge at present in use in coal mines one made of nitroglycerine mixed with ammonium carbonate or chloride. "By the addition of this carbonate of ammonium (or chloride), the temperature of the explosive gases is so small that flashing of the gases is prevented."

U. S. Letters Patent No. 397440, February 5, 1889, have been granted L. Plom and J. d'Andrimont for a "Method of Blasting," which consists in making a cavity near to the end and on either side of the bore-hole, filling the lower part of this lateral cavity with the

* Proc. Nav. Inst. 14, 758; 1888.

explosive, and plugging the bore-hole with a wooden plug which carries the fuze. It is claimed that the explosive will thus be rendered more efficient, and that any tendency to blow out through the bore-hole will be prevented.

J. R. Eaton states that after making hydrogen phosphide in the usual way by boiling phosphorus in potassium hydroxide, he allowed the apparatus to remain *in statu quo* for three days, in order to show his class that the phosphorus remained in the liquid state after cooling, and at the end of this time finding it liquid, he lifted the flask and gave it a slight shake, when it immediately exploded and the phosphorus solidified at once. He suggests that it was due to gas being condensed by adhesion around the phosphorus as the solution cooled, and that the shaking caused a rapid evolution of this gas.

He states that nitrogen iodide will explode when wet,* if it has been allowed to stand twenty-four hours in aqua ammonia, and that when freshly prepared, if partially dried and then scattered over the surface of a tank of water, it will repeatedly explode for hours after by slightly agitating the water.

He many years ago used a mixture of potassium chlorate and phosphorus by placing the powdered salt (no more than will cover a nickel, if exploded within doors) upon a board, and wetting it with a solution of phosphorus in carbon† disulphide (an inch of phosphorus will dissolve in an ounce and a half of carbon disulphide in a few minutes). In from five to ten minutes, or as soon as the mixture is dry, touch it with a long pole, or even stamp on the floor, and a loud explosion will ensue. A quantity sufficient to cover a dollar will shatter a thick plank and make a considerable hole in the ground.—(*Science* **13**, 449; 1889.)

The high temperatures attainable with Dr. Hare's oxyhydrogen blowpipe have long been known to chemists, and its practical use in the "lime light" has been quite common. Formerly the gases were stored for use in tin gas-holders or rubber bags, and were forced out under a moderate pressure, but within the last decade it has become the custom to store the gases up in stout steel or wrought iron cylinders, under a pressure of many hundred pounds, and the supplying of these compressed gases has become a very considerable industry.

With the cheapening in the cost of the production of oxygen, the

* Proc. Nav. Inst. **12**, 424; 1887. † Ibid. **15**, 85; 1889.

substitution of compressed coal gases for hydrogen, the continual improvements in methods and means for compression of the gases, and in the form and proportions of the blowpipe, it is not surprising to learn that new commercial applications are continually being found for it, and that in its present form it bids fair to rival in cheapness and to surpass in convenience the various electric methods which have recently been devised for autogenic welding. An account of some of the most recent advances will be found in a paper by Thos. Fletcher (*Jour. Soc. Chem. Ind.* **7**, 182–185; 1888) on a "New Commercial Application of Oxygen."

The explosiveness of these gaseous mixtures is one of the well known facts of chemistry, and several examples of accidental explosions have already been cited in these Notes,* but as the use of the compressed gases is increasing very rapidly and bids fair to become widely extended, we quote the following "Notes on the Explosion of Gas Cylinder," by W. N. Hartley, from the *Chem. News* **59**, 75-76; 1889:

On January 28 a lamentable and fatal accident happened to Mr. Thomas Arthur Bewley, by the explosion of a cylinder of compressed gas at the shipbuilding yard of Messrs. Bewley & Webb, East Wall, Dublin. The deceased gentleman established machinery for the compression of gases, and supplied the trade with compressed coal-gas and oxygen in wrought-iron cylinders. Owing to the uncertainty of the exact cause of the explosion, a good deal of anxiety has been excited amongst the public.

The combustible gas, whether hydrogen or coal-gas, was stored in cylinders painted red and the oxygen in cylinders painted black. This rule was intended to be invariable. On December 27, Mr. Chancellor, of Sackville Street, sent an urgent request for a bottle of oxygen, but there being none of the black cylinders available, owing to the excess of business at Christmas time, Mr. Chancellor was informed that he could be accommodated with oxygen in a red cylinder. This cylinder was returned on January 15. Afterwards, an application was made for a bottle of hydrogen and one of oxygen. It had been forgotten by the deceased that this bottle was charged with oxygen, and, being red, it was simply filled up and sent out as hydrogen.

It was attached to a lime-light apparatus when the discovery was

* Proc. Nav. Inst. 14, 166–167; 1888.

made that it contained mixed gases, for the india-rubber connecting tube was blown off as soon as the gas was ignited at the burner. It was placed on one side and labeled "mixed gases." Two days afterwards the bottle was sent back to Mr. Bewley and was placed on a table in the drawing office, where it remained until the fatal occurrence.

Instead of allowing the gas to blow off, he tested a small quantity of the gas in a tube in presence of one of his foremen, who described the "spirt" with which it went off when a lighted match was applied to the mouth of the tube. The flame seen was a small blue one. He stated to the foreman that, as the amount of inflammable gas was so small, he intended to use the cylinder himself as an oxygen cylinder. As the pressure was higher than he required, a portion of the gas was allowed to pass into another black cylinder, which reduced its tension from 800 to 400 pounds (the breaking strain of the bottle is well over 2000 or 2500 pounds). It must be remarked that the connecting tube did not fit satisfactorily, and that at the time (2 o'clock) a small gas-jet was burning in the room. At 4.25 the explosion occurred, but as no one had been in the drawing office but Mr. Bewley himself, the conditions under which the explosion took place are not precisely known. The evidence, however, is fairly conclusive.

In the first place, it must be stated that the metal of the cylinder was perfectly sound, and in the interior there was no appearance either of oil or of rust. While the upper part of the cylinder was blown to pieces, the body of it struck the arch over a window and caused the wall to bulge; it then ricocheted apparently against the wall, and passed through a window opposite to where it had first struck. The upper end of the cylinder was found at a much greater distance from the building.

One witness, who saw a gauge on the bottle marking 800 pounds, believed that the cylinder had been overcharged, and that disruption occurred simply by the elastic force of the gas. Having examined the premises, I was in a position to state at the inquest that the nature of the explosion was most certainly that of a detonation. The table and drawers were splintered into match-wood, and the glass from the window, as it lay on the ground, presented the peculiarities of fracture which are characteristic of such an explosion.

The examination of the top of the cylinder just below the shoulder showed that the fractured metal at this part had a different appear-

ance from the other fractured surfaces. Instead of being bright it was burnt all the way round, that is to say, covered with magnetic oxide. Moreover, the medical evidence showed that death was caused by shock, and the force of the explosion threw the body out of the room. While the left hand was severed from the arm at four inches above the wrist, the right was charred, and singeing was noticed on the right leg, and the hair was crisp from the same cause.

Without doubt the explosion occurred from the detonation of mixed gases within the cylinder.

The valves of both cylinders, which had been connected by a tube previously, were found wide open. The ignition of the gases was most probably caused, not by any chemical action spontaneously taking place within the cylinder, but either by a leakage which was tested by applying a match, or, the leakage being serious, the gases were fired by a lighted gas-jet. It must be remembered that what was believed to be the same gas had previously exploded in the lime-light apparatus, merely blowing off the india-rubber tube, but the valve being but slightly open, the explosion was not communicated to the interior of the cylinder because the pressure was higher and the issuing gas was traveling at too great speed for the temperature of ignition to be maintained in the stream issuing from the small orifice in so large a mass of metal.

For the better understanding of this explanation I will refer to a very simple experiment. Carbon monoxide stored in a gas-holder under a pressure of six inches of water, cannot be burnt from an ordinary gas jet, but if the size of the orifice is enlarged to $\frac{1}{16}$ or $\frac{1}{8}$ of an inch, it can be made to burn when the pressure is somewhat reduced. There is no material alteration in the conditions of the experiment if the gas be mixed with air or oxygen. In fact, the temperature of ignition cannot be maintained in contact with the cooling mass which surrounds a small orifice, or with the gas under a very rapid rate of flow.

We cannot precisely ascertain the temperature of ignition or the rapidity of explosion of the mixture of gases contained in the cylinder, but it certainly contained a large excess of oxygen, and the conditions under which it was first found to be dangerous were different and less favorable to explosion than after the pressure was reduced.

The verdict of accidental death was coupled with a recommendation that the public should be protected from similar accidents by a Government stamp being fixed to all cylinders used for such purposes.

But greater safety would be secured by making the fittings for hydrogen and oxygen cylinders so entirely different that it would be practically impossible to charge a cylinder with the wrong gas.

In *Ding. Poly. Jour.* **267**, 416–419; 1888, is an article by L. Jawein and S. Lamansky, on the "Decrease of the Illuminating Power of Naphtha Gas by Admixture of Air, and the Explosibility of such Mixtures," which contains the results of an examination of such naphtha gas as is manufactured in Russia from naphtha and naphtha residues, for illuminating purposes. Owing to the difficulty of obtaining a general average sample of the gas, the experiments were all made on one day; the required amount of gas being led into a small gas-holder, which also contained the air for mixing. The explosibility of the different mixtures was ascertained by subjecting them in a eudiometer to the action of an electric spark, and the following results were thus obtained:

Vol. of Gas.	Vol. of Air.	Explosion.
1	4.9 — 5.2	None.
1	5.6 — 5.8	Feeble.
1	6.0 — 6.5	Violent.
1	7.0 — 9.0	Very violent.
1	10.0 — 13.0	Violent
1	14.0 — 16.6	Feeble.
1	17.0 — 17.7	Very Feeble.
1	18.0 — 22.0	None.

A mixture of naphtha gas and air is therefore explosive if gas and air be in the proportion of 1 to 5.6 — 17.7 by volume, or 1 to 85 — 94.4 by weight. Of course these figures are only accurate for the sample of naphtha gas experimented upon. After all, it is not likely that the figures will vary much with different naphtha gases, the proportion for marsh gas being 1 vol. of gas to 6 — 16 vol. of air.

We have already recorded in these Notes* the suggestion which has been made to employ a mixture of powdered magnesium and gun-cotton for use as a flash-light in photography, and we have since watched for the accidents which it seemed inevitable must follow. Recently we have learned through private channels that such an accident occurred in New York on the evening of May 1, 1889, while a photographer was attempting to take a picture of the Centennial

* Proc. Nav. Inst. 14, 443; 1888.

Arch. For this purpose he employed from six to seven ounces of the mixture, which was placed in a tin tube about six inches long and three and one half to four inches long. This tube was fastened on the end of a wooden handle, so it could be held above the head at arm's length, like a torch. On igniting the mixture and raising the holder above the head, an explosion ensued which was accompanied with a violent report. The photographer was thrown down and rendered unconscious, but fortunately (and probably because of the position in which the tube was held) he escaped with only severe burns on the face, arm and hand.

The *Journal of the Society of Chemical Industry* **7**, 244; 1888, gives the following account of the trade in explosives in France in 1885–1886, as rendered by Her Majesty's Attaché:

"As regards imports, we should remember that gunpowder, gun-cotton, nitro-glycerine, picrates, and fulminate are all prohibited; that dynamite is allowed to enter at a duty of 2 francs 50 centimes per kilo under special regulations; and that loaded cartridges are admitted, under special arrangements, at a duty of 25 francs per 100 kilos.

"The imports of dynamite and loaded cartridges into France in 1886 were as follows: From Belgium, 68,605 kilos of dynamite, and cartridges, *nil*; from England, dynamite, *nil*, and 133 kilos of cartridges; from Italy, dynamite, *nil*, and 18 kilos of cartridges; from Switzerland, dynamite, *nil*, and 1458 kilos of cartridges; giving totals of 68,605 kilos of dynamite and 1609 kilos of cartridges.

"Belgium is the sole importer of dynamite.

"The exports of explosives have been as follows: Military powder, 994 kilos in 1886, and *nil* in 1885; sporting powder, 30,018 kilos and 13,924 kilos; mining and foreign trade powder, 833,164 kilos and 817,779 kilos.

"The production of dynamite and gunpowder is controlled by the Excise, and official returns show the sales to have been as follows: Sporting powder, 433,518 kilos in 1886 and 490,562 kilos in 1885; mining powder, 2,559,128 kilos and 2,815,258 kilos; military powder, 164,286 kilos and 171,888 kilos; powders sold of all kinds on the Swiss and Italian frontier districts of Corsica, Monaco, and Tunisia, 148,967 kilos and 100,193 kilos; dynamite, 396,618 kilos and 447,359 kilos; nitro-glycerine, 668 kilos and 774 kilos.

"The total amount of gunpowder that paid excise was 4,169,081 kilos in 1886, and 4,409,604 kilos in 1885.

"The excise on gunpowder gave 12,970,255 francs (£518,808) in 1886, as against 13,862,441 francs (£554,496) in 1885."

The British consul at Palermo reports that the very unsatisfactory state of the sulphur trade, and of the low prices this article finds in the market, are causing great anxiety to the owners of sulphur mines and to those who trade in sulphur. For the last five years the prices have been steadily decreasing; and whereas at one time merchants insisted on a profit varying from 21 to 42 centimes, they are now only too glad to obtain a profit of 4 and sometimes 2 centimes. The reason for this is to be found in the fact that the production of the mineral during the last thirty years has been excessive, and at present the annual production has been from 600,000 to 700,000 quintals over and above the ordinary consumption. The consequence is that the sulphur accumulates at the mines and at the outports, thereby causing the owners to get rid of their produce at any price. Another circumstance that has tended to depreciate the value of sulphur is that Sicilians cannot be brought to bind themselves into companies or associations; and so the opportunity of being able to close their mines for a few years until the stock is all disposed of at a fair profit is lost.

The French *Bulletin du Ministère des Travaux Publics*, for November last, says that the total quantity of sulphur contained in the Sicilian mines before workings were commenced is estimated at 65,000,000 tons. The quantity produced from 1831 to 1885 is stated to be 8,353,091 tons, and previous to this period about two millions, making a total of 10,353,091. When it is considered that to obtain this quantity about fifteen million tons were turned over (as generally a third is lost in the treatment), it results that the quantity still available is at least 50 million tons, and supposing that the average production for the future should be maintained at about the same proportion as in past years, the Sicilian mines may continue to be worked for another century.—(*Jour. Soc. Chem. Ind.* 7, 139, 140; 1889.).

The yield of the sulphur mines in Northern Italy was 21,663 tons in 1887, as against 23,274 tons in 1886. The decrease is partly due to the diminished yield of the Boratella pits, which have been partly worked out, and to the collapse of the Cesena Sulphur Company, Limited, which has pretty well exhausted the basin of the Romagna. The company has spent large sums in the search for new places of

production, and in the attempt to work further those commenced by its predecessors, but without avail; and after a few years the company saw itself confined to the pits at Boratella. The production of the company of the Romagna shows a slight increase. The Montivecchio shaft, which belongs to this company, is not yet complete.

Permanent progress is noticeable in the provinces of Pesaro and Urbino. The new shaft in the mine of San Lorenzo, in Zolfinelli, has increased the daily yield of the latter to 200 tons of ore. The loss of work in the Boratella mines has caused many of the workmen to turn again to the old Casalbono mines, which they work in small gangs. The yield has so far only been moderate.

The treatment of the crude sulphur has undergone little modification. A new refinery with three ovens and 34 refining kilns has been erected at Porto Corsini, near Ravenna. It turns out 6000 tons a year. In 1887 the various refineries have produced 24,000 tons of ground sulphur, an increase of 3516 tons over last year. The exact quantity of finely ground sulphur produced is not known, but it probably represents $\frac{1}{12}$ of the total refined sulphur. The Albani Pit Company produces special preparations, and to meet the increased demand, especially for their acid sulphur, has induced them to enlarge their new mill at Fano. During the last wine season the Pesaro manufactory turned out 9500 tons of acid sulphur containing 0.22 per cent of sulphuric acid, and 1105 tons sulphur containing between one and eight per cent of copper sulphate.

The presence of the above quantity of sulphuric acid has been found the most suitable in the treatment of the vine disease. This acid is not added, as is done in some parts of Italy, but is a natural adjunct of the preparation. Artificial acidification does not yet appear to have been introduced in the factories.

Though almost the whole production was disposed of during the wine season, prices have been kept low by Sicilian competition.

The average price per centner for the year has been:

Crude sulphur,	8.75 francs.
Refined in loaves,	10.40
Sulphur in sticks,	13.00
Coarsely powdered,	13.10
Sublimed,	14.50
Acidified powdered,	17.65
Powdered and containing copper,	21.50
Flowers of sulphur, washed,	35.00

The following are the statistics for 1887 :

Province.	Number of Pits in Work.	Quantity of Crude Sulphur. Tons.	Total Value. Francs.	Number of Workmen.		
				Grown up.	Under 15 Years.	Total.
Anicone.....	1	34	2,680	96	..	99
Forli	10	13,026	1,095,006	1,231	7	1,238
Pesaro and Urbino.	5	8,603	668,269	1,304	48	1,352
Totals.....	16	21,663	1,765,955	2,631	55	2,686

—(*Jour. Soc. Chem. Ind.* **8**, 142 ; 1889 ; from *Chem. Zeit.* **12**, 1659.)

The *Bulletin du Musée Commercial*, March 24, 1888, states that there are in Chili about 50 manufactories of nitrates. The total production of 47 of these factories during the month of December, 1887, amounted to 659,464 metric quintals, or 65,946 tons ; it was 67,745 for the month of November. Assuming that these figures were maintained for the other months, there would be produced in 1887 about 800,000 tons. This is almost double the amount exported by Chili in 1886 and 1885, when the syndicate of manufacturers decided to diminish the production.

The *Journal of the Society of Chemical Industry* **8**, 152–153; 1889, states that the shipments of nitrate to the United States during 1888 were 472,500 bags, against 555,000 bags in 1887, 522,750 in 1886, 270,323 in 1885, and 437,234 in 1884. The quantity to arrive for Atlantic ports is 224,000 bags, against 239,000 in 1888, 238,500 in 1887. The total visible supply is 310,000 bags, against 301,940 in 1888, 311,266 in 1887. The quantity to arrive in Europe is 2,527,000, making the visible supply there 3,112,000 bags, against 2,927,500 bags in 1888, and 2,070,000 in 1887. The deliveries at San Francisco during last year were 60,000 bags, making the total deliveries in this country 515,000 bags, as against 534,347 in 1887 and 454,760 in 1886. In Europe the deliveries were 4,712,000 bags, making the total for the world 5,227,000, as against 4,164,347 in 1887, 3,522,260 in 1886, 3,278,686 in 1885, and 3,974,071 in 1884. Tables are given showing the condition of the trade with the United States and Europe annually from 1883 to 1889.—(*Eng. and Mining Journal.*)

A. Muntz and V. Marcano have been studying the " Proportion of Nitrates contained in the Rain in Tropical Regions," and they have examined 121 specimens from Caracas, Venezuela, which have

yielded them the following average weights of nitric acid per liter: Specimens from July, 1883, to July, 1884, 2.45 mgr.; specimens from January, 1885, to December, 1885, 2.01 mgr.; or for a general mean, 2.23 mgr. The richest specimen of rain (taken October 19, 1883) gave the enormous quantity of 16.25 mgr. and the poorest 0.20 mgr.

Comparing these results with those obtained in Europe we find that Boussingault obtained an average of 0.18 mgr. at Liebfrauenberg, Alsace, and Lawes and Gilbert obtained an average of 0.42 mgr. at Rothamsted, England.

The authors attribute the great richness of the rains in the equatorial regions to the high electrical tension and frequent discharges which occur there, and which serve to oxidize the atmospheric nitrogen.—(*Compt. rend.* **108**, 1062–1064; 1889.)

A second edition of "Les Explosifs Modernes," by P. F. Chalon,* has appeared, which has been augmented by over one hundred pages, which are devoted to a dictionary, or rather an encyclopædia, of explosives, and which adds very much to the value of the book.

A new book by Lieutenant Max von Förster, superintendent of the gun-cotton factory of Wolff & Co. at Walsrode, is announced under the title "Schiesswolle in ihrer militärischen Verwendung," Berlin, 1888.

The "Lectures on Chemistry and Explosives," which were delivered by Charles E. Munroe to the officers under instruction at the Torpedo Station in 1888, have been issued from the Station press in the form of a large octavo of some 320 pages, together with plates illustrating the methods of manufacture of gun-cotton.

*E. Bernard et Cie., Paris, 1889, *vide* Proc. Nav. Inst. **14**, 773; 1888.

Fig. 1.

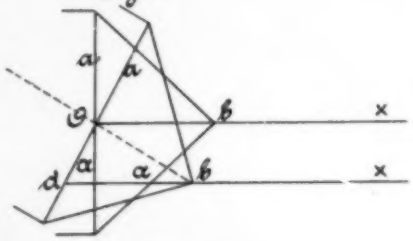


Fig. 7.

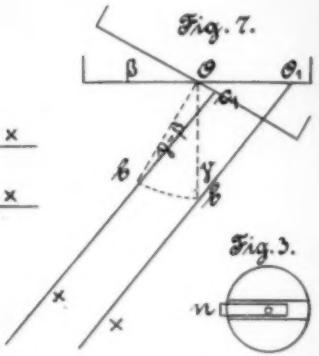


Fig. 3.

Fig. 2.

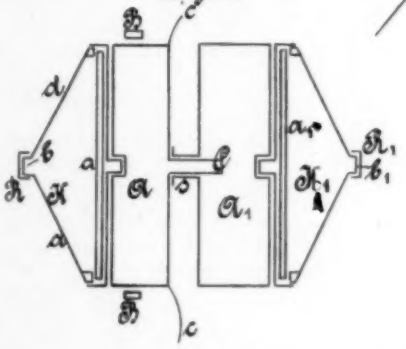


Fig. 8.

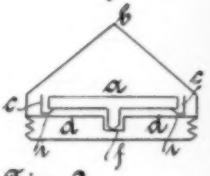
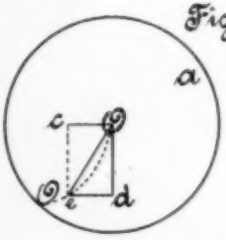


Fig. 9.

Fig. 6.



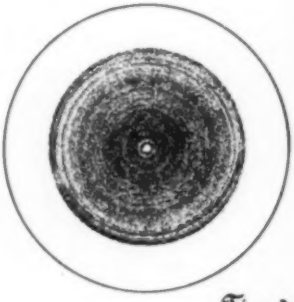


Fig. 5.

Fig. 4.

To face page 513.

PROFESSIONAL NOTES.

A METHOD OF REGISTERING THE ROTATION OF A SHOT BY PHOTOGRAPHY.

By F. NEESEN, Professor in the United Artillery and Engineers' School at Berlin.

[Translated from the *Archiv für die Artillerie- und Ingenieur-Offiziere des deutschen Reichsheeres*, January–February, 1889.]

The possibility of estimating the rotation of a shot by means of photography was suggested by Captain A. D. Dregar several years ago. His idea was to place a sensitized plate inside the projectile, but he never carried out the plan experimentally. I have endeavored to prove the practicability of the scheme by means of a model, and for this purpose had constructed an apparatus, the principle of which may be thus described:

Upon a sensitized plate *a* (Fig. 1) a photograph of the narrow opening *b* is made by the ray of light passing through it. Inclining the plate changes, of course, the position of the photograph upon it. Through the advice and assistance of Prof. H. W. Vogel I became convinced that if a photographic chamber, completely closed except a small opening 1 mm. in diameter, were given a quick to and fro motion, a sharp trace of the ray of light *x* would be received upon the plate *a*. I accordingly arranged an apparatus in the following manner:

A (Fig. 2) is a short metallic cylinder having a screw-thread cut upon it outside, on which is a revolving ring *B*. Two short arms *cc* are fastened to *A* and put in a ring of the Bohneuberger apparatus. The sensitized plate is placed in the chamber *K*, which is screwed into *A*. A cover *d* closes the chamber *K*, and at the same time holds securely the plate *a*, which moves upon a plate-spring. In *d* is the opening *b* ½ mm. in diameter; a cap *R* closes this opening. *A* carries further the sliding-pin *C*, over which is slipped a second metallic cylinder *A* and a chamber K_1 similar to *K*. Besides the cap *R*, a slide valve *n* (Fig. 3) is used to close the opening *b*. The valve is thrown out by centrifugal force during the revolution of the cylinder *A*. A cord is wound upon *s*, the rapid drawing off of which imparts rotating motion to the cylinder *A* with the chamber K_1; a spring may be used instead of the cord. By the revolution of the ring *B* the center of gravity of the apparatus is displaced and a photograph obtained of the oscillations of the axis of rotation.

In this manner the sketches in Figs. 4, 5, and 9 were obtained, which need no explanation.

EMPLOYMENT OF THE SHOT.

I. *Rotating Plate.*

If it is desired to obtain the picture of the oscillation of a rotating shot, the arrangement is very simple. The point of the shot must be capable of being unscrewed and the sensitized plate placed inside. The plate is of metal, upon which the negative paper is secured, or it is coated directly with bromide of silver; a small hole *b* is cut through the nose of the shot, which is uncovered automatically, as already explained, by the flying out of the slide valve *n*.

The point of light describes a spiral by the motion of the shot. To obtain from this the horizontal and vertical motions of the axis of the shot, two rounds must be fired under similar conditions, but the initial angle of the projected light ray must be different. In the first round the gun may be laid as in Fig. 1, that is, so the ray of light will strike the center of the plate. By the vertical inclination of the shot through the angle α, the ray of light passes in the direction d, so that a circle is described with the radius Od. At the same time, the horizontal deviation β will cause the ray to pass in the direction e. In reality, then, the track of light takes the direction Oe. Oe, it will be observed, is a spiral.

$$Oe^2 = Od^2 + Oe^2.$$

But from Fig. 1,

$$Od = Ob \sin \alpha. \qquad Oe = Ob \sin \beta.$$

Therefore,

$$Oe^2 = Ob^2 (\sin^2 \alpha + \sin^2 \beta),$$

in which α and β are to be found.

The original position of the gun with reference to the sun's rays is now changed, so that for a second round with the same elevation the gun is laid so as to fire through a vertical line passing through the sun. In other words, the gun is laid in another vertical line so as to obtain a second equation for α and β.

It is necessary only to consider the last case. The gun being turned through the horizontal angle γ from the first vertical line, the length Od remains the same, but Oe changes.

The light ray first strikes the plate at O (Fig. 7), but after the revolution of the axis of the shot in the horizontal angle β, at e_1. As already stated, by the vertical inclination the point of light on the plate is shifted from Ob to O_1, and is calculated from O_1, so that by both variations the resulting point e is distant from the center of the plate:

$$Oe_1^2 = O_1d^2 + Oe_1^2. \qquad (1)$$

But

$$O_1d^2 = Ob^2 \sin^2 \alpha,$$

and

$$Oe_1^2 = Ob^2 \tan^2 (\gamma - \beta).$$

Substituting in (1),

$$Oe_1^2 = Ob^2 [\sin^2 \alpha + \tan^2 (\gamma - \beta)],$$

which is the second equation for α and β.

The variations in the curves thus obtained show that in the first case both α and β cause an increase of Oe, while in the second case the horizontal angle β produces a decrease of Oe as long, at least, as the axis of the shot does not pass through the vertical line passing through the gun and sun.

The only question that arises from these experiments, and it can only be decided by actual trial, is whether it is possible to separate the single spiral curves from each other.

II. *The Stationary Plate.*

In order to obtain the track of light on a non-rotating plate, the following arrangement can be made (Fig. 8):

The sensitized plate (a) is secured with a pin in a hollow bed f, care being taken that it does not touch f. It is held in suspension by two small wires II. In order to prevent any disturbance of the plate by the shock of discharge, a ring c is used, on the inner half of which the plate a is placed. C is enclosed in a cylindrical room filled with a fluid, which also fills the hollow chamber f and the space between a and d, so that the shock is dissipated by the liquid and all strains upon the plate divided. As a bears upon the shot only on the small pin f, it remains steady during the rotation of the projectile.

The plate is kept from flying back upon its seat at the instant of discharge by ribs cast on the inside of the ring *c*. The tendency of the plate to rotate with the shot is further diminished by the fact that its center of gravity is thrown as far as possible out of the axis of revolution.

From the curve *Oo* (Fig. 6) which is made upon the plate, and from the co-ordinates *Od* and *Oc* of this curve, entire deviations of the axis of revolution are obtained for every angle of α corresponding to β. A. G.

QUADRANT ELEVATION FOR NAVAL ORDNANCE.

By Captain P. J. R. Crampton, R. A.

The improvement in shooting which has followed the use of the clinometer instead of the tangent scale, in laying guns for range, is most remarkable. The cause of the improvement is chiefly to be found in the fact that with a clinometer a gun, or even a number of guns, may be laid, mechanically so to speak, for exactly the same range, instead of depending on the uncertain skill of a variety of individuals, thus eliminating all chance of inaccuracy due to the personal error on the part of the Nos. 1.

This improvement becomes particularly apparent when verifying or picking up ranges by means of trial shots. For comparison let us take the case when verifying a range (1) with, and (2) without the use of a clinometer. In the first case the following method will probably be adopted. The leeward gun will be fired at an estimated range; say, this round apparently falls just over the object fired at. The next gun would be fired with the same elévation; say, this round falls short. Theoretically speaking, the elevation and consequently the range are correct, but it would not be safe to accept it as such without firing another round or two, or a salvo of two or three guns, to test the accuracy of the two first rounds, which would be a waste of both time and ammunition. Take now the case when a clinometer is used to give the elevation, and say that similar results have been obtained in the first two rounds, one round over and the next short, both guns having been laid by the same quadrant elevation. The results of these two rounds would be quite sufficient to determine the range, as any cause of inaccuracy must now be looked for inside the gun. The advantage of being able to lay guns from behind cover, or at night, or on an invisible target, by means of the clinometer, is of course well known.

An extension of this principle to the naval service would be most desirable, as it is evidently adapted for use in connection with the "Director" system at present in the service, and many additional causes of error which are now inseparable from naval gunnery would be removed thereby; but to be successfully applied some modifications are necessary. A spirit clinometer, owing to the motion of the ship, would be useless, and consequently quadrant arcs would have to be used instead. The index plates at present in the service are certainly not so accurate as a clinometer, but no doubt they might very easily be improved by lengthening the radius. The exact moment the ship is on a level keel, or rather the moment when the line formed on the plane of the racers by the intersection of the plane of departure is in the horizontal plane, must also be determined. This moment once determined, the guns must be fired instantaneously, as the ship will be moving with more or less angular velocity. This instantaneous firing is necessary in any case, whether the gun is laid by tangent sight or quadrant, and here the errors inherent to the use of the tangent sight on land are vastly increased. Personal error is bad enough when the gun platform is steady; in this case it is constantly moving, and the No. 1 has to keep his eye on the target, the trunnion sight, and the notch of the tangent sight at the same time. It is sufficiently hard to focus these three objects when they

are all in the same straight line; when one of them is at a distance from this line and constantly moving, the difficulty is greatly increased. Not only has the No. 1 to determine by the eye the moment the sights are aligned with the object, but he has also to fire the gun instantaneously, otherwise commencing to pull the lanyard before the object comes into line; even when guns are fired by electricity it is impossible to make the hand obey the eye instantaneously. For these reasons it is desirable that the gun should be fired automatically, and electricity lends itself admirably to this purpose.

The difficulty at present is to get an instrument which will show, under the various movements made by a ship at sea, the absolute horizontal, and which at the same time will not be put out of adjustment by the shocks of discharge of the armament. Various plans have been adopted to obtain a reliable ship's pendulum or clinometer, which may be divided into two main classes—those of the nature of a pendulum, and those like gyroscopes. Now a well suspended gyroscope, such as that made by Professor Piazzi Smith, gives excellent results so long as there is a horizontal plane to start from, the difficulty being to start the gyrating disk in the true horizontal plane when the ship is already rolling, which difficulty I believe no one has as yet got over, and even if it were surmounted, the first discharge of a heavy gun would put it wrong. The same objection applies to pendulums and instruments such as that constructed by Mr. Froude, in which the discharge of a heavy gun would almost to a certainty put the long pendulum out of adjustment. This would not necessarily vitiate the graphical record so ingeniously obtained with this instrument, as any inaccuracies in their swing, caused by shocks to the ship or from acceleration, are at once observable on the tracing, and can be ignored when the results are being tabulated, but this would not be applicable to the firing of a heavy gun.

The instrument about to be described is not of so ambitious a nature as Mr. Froude's, which records the angular displacements of the ship and its inclination to the wave slope during the whole of its roll, but merely a clinometer which will show the true horizontal through a space of about 1° on either side of the ship's normal position in calm water. This limiting of the scope of record is necessary in order to steady the so-called pendulum between each roll, for the fact has been established that if a pendulum of long period in comparison with that of the ship be suspended at the center of gravity of the vessel, it will remain vertical if steadied at the end of each roll, and so extinguish any moment it may have previously acquired during the preceding roll; whilst a pendulum of comparatively short period will tend to remain normal to the wave slope, if the ship rolls with the waves. Now all clinometers are pendulums in disguise, and generally pendulums of a very short period; they would, therefore, when the period of the ship coincides with that of the waves, tend to lie in a normal to the wave slope; but as ships do not as a rule roll into the waves, and as the latter are at all times of uncertain shape and size, a short pendulum will acquire a variety of moments due to the uncertain movements of the ship. But should the pendulum be bound, so to speak, during say nine-tenths of its course, there will not be time for any force except that of gravity to act, and it will show the true vertical. It may be said, should the ship only roll through one degree or less on each side of the vertical, the principle will not apply. This is true; but a modern ironclad rolling takes about 10 seconds to complete each roll. The motion therefore is so slow that no accelerating or other force is set up and the instrument is still true. What is meant will easily be seen by reference to the section. The instrument is supposed to be centered in a plane parallel to the plane in which the guns are traversed, and is capable of being traversed in the same manner as a gun on a central pivot. When required for use, it is put into a position in which a vertical plane drawn through the centers of the two electro-contacts *e e* will be parallel to the plane of departure of the gun. It is also supposed to be as nearly as possible at the center of gravity of the ship.

PATENT No 14,216.

Fig. 4.

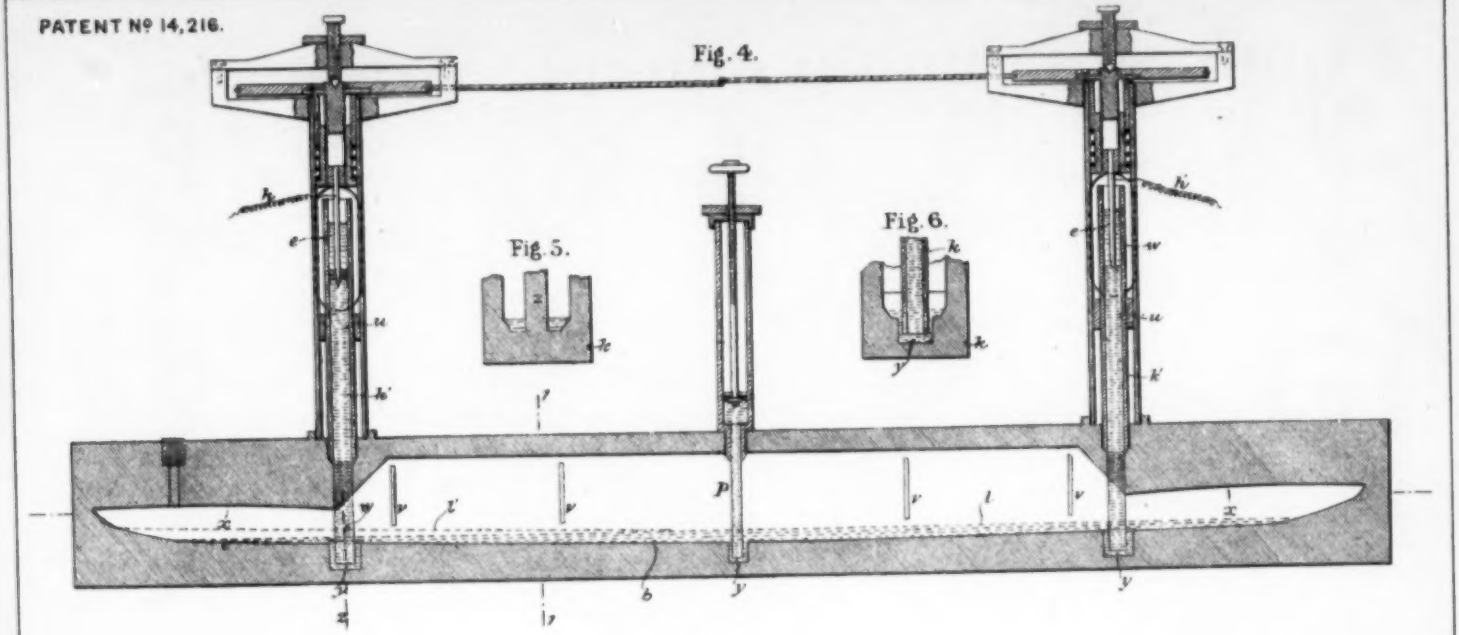
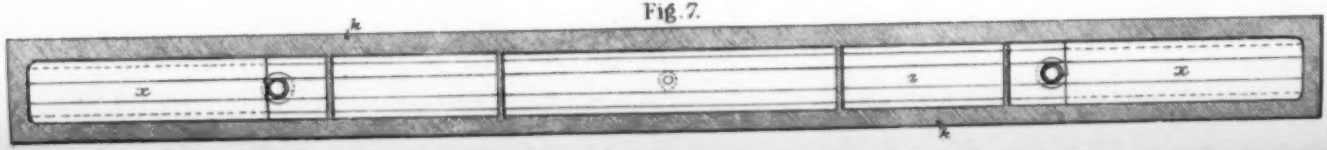


Fig. 5.

Fig. 6.

Fig. 7.



To face page 219.

The vessel *k* is an iron box with a double trough at the bottom (*vide* figure), with three recesses *y* into which two tubes *k'* and one tube *p* dip. These tubes are hermetically screwed into the top of *k*. To fill the vessel, petroleum or some other non-conducting liquid is poured in through the filling hole until filled. A small quantity of mercury is then poured down until it rises as high in the trough as shown in the sketch. In doing this it will displace an equal bulk of the petroleum. The filling hole is then closed by the screw plug, whilst more mercury is poured down through the tube *p*; as the petroleum cannot now be displaced, the filling hole being plugged and the bottoms of the tubes *k'* and *p* being below the surface of the mercury, the latter will rise in the tubes *k'*. Sufficient is poured in to bring the level up to about the height shown. This level can be exactly regulated by means of the piston and screw shaft in continuation of the tube.

On the vessel *k* being tilted by the motion of the ship, the mercury will run down to one end and fill up one of the recesses *x x*. The level of the top of the column of mercury in the tubes *k' k'* altering with the change of level of the mercury in the troughs until a point *w* is reached, at which the line of the top of the mercury continually cuts the same point in the center of *k'*. This is arranged by the shape of the recesses *x x*, and consequently no further amount of roll will alter the level of the top of the columns of mercury. This will take place after a roll to either side of about 1°. The level of the columns will then remain the same until the mercury is poured from one recess to the other by the return roll, when the true horizontal will again be maintained for about 1° on either side of the vertical.

The section in the figure represents the level of the mercury at rest; *k'* after the instrument has been tilted 1° out of the horizontal; *b* is the bottom of the trough; *vvvv* are screens to increase the inertia of the petroleum.

The conditions already laid down are fulfilled by this arrangement. The pendulum is steadied between each roll, and the period during which forces other than gravity can act upon it is very short. At any rate it will start fair after each roll, and the quantity of mercury being small, the moment of inertia is reduced as far as possible, it also will be destroyed between each roll. The shape of the bottom of the trough is a very flat cycloidal curve, except at the ends, where it is steeper; this is to prevent waves being formed on the surface of the mercury. The inner surface of the vessel *k* is copper-plated, so that the mercury when touching it will amalgamate on the surface and so prevent friction.

The clinometer is arranged to complete a voltaic circuit, and so fire the guns automatically when the ship is in its normal position, as follows:

The tops of the tubes *k' k'* terminate in glass tubes *w w* which are of the same bore as *k' k'*, and into which tubes two steel rods *e e* project. The depth to which they project is regulated by means of micrometer screws worked by pulleys as shown in the drawing, and the two pulleys are connected by a crossed gut band, so that by depressing one rod the other is raised an equal amount, and *vice versa*. The rods being fixed so that their lower ends are in a plane parallel to the plane of the gun racers, and the ship being on a level keel, the screw piston shaft is screwed up or down, and the mercury in the tubes so adjusted as just to touch the ends of the rods *e e* (which are isolated from the rest of the instrument, the latter itself being isolated from its support). If now the rods are connected to opposite poles of a voltaic battery by wires, the circuit will be complete and the current pass; but if the ship rolls the least out of the vertical position, the mercury in one tube will sink and rise in the other end, the circuit will then be cut, as the petroleum which lies on the top of the columns of mercury is a non-conductor.

If now a low tension tube (such as one of the electro vent-sealing tubes now in the service) be connected in series with the circuit, it will explode when the ship is vertical. If more than one gun is to be fired, it will be better to con-

nect the tubes which are to fire them in parallel with a central station, the poles of this station to be connected in series with the clinometer circuit. A firing key and a switch which cuts out the clinometer circuit, are also placed in the circuit.

Any small errors in range which may be due to the angular velocity of the ship when rolling, or even to incorrect estimation of range, can be corrected by means of the pulleys and micrometer screws, which can, if necessary, be worked by an electric clock from the conning tower. When the switch handle is turned on to the direct circuit, the guns in the battery will be fired as soon as the firing key is pressed down. When the handle is turned to the clinometer circuit and the firing key pressed, the guns will fire as soon as their racers are in the horizontal plane; at any moment, by taking the finger off the firing key the circuit can be cut. Other safety arrangements can be applied to the guns themselves.

THE BASIC DUPLEX PROCESS.

In the Bulletin of the American Iron and Steel Association for July 3d, Mr. Jacob Reese gives the following description of his latest process for the manufacture of steel:

The basic duplex process consists in blowing molten metal with an air-blast while held in an acid-lined converter until the silicon is eliminated and the carbon is reduced to about one-half of one per cent, then transferring the desiliconized metal (minus the slag) into a basic-lined open hearth, and there boiling out the carbon and dephosphorizing the metal in the presence of a basic slag. This process will work metal of any and every quality. If the metal is high in silicon, the silicon is removed in the acid-lined vessel and the phosphorus and carbon in the basic-lined vessel, so that the silicic acid or dirt formed in the elimination of silicon will not be present in the dephosphorizing period, and a purer metal will be made than by either the basic Bessemer or the basic open-hearth process. The time required to make a heat by the basic duplex process is from three to four hours, the expense of converting being about a dollar a ton less than by the basic open-hearth and a dollar a ton more than by the basic converter.

This process may be practiced to advantage at Pittsburgh, Harrisburg, and in Eastern Pennsylvania; at Richmond, Lynchburg, Low Moor, Milnes, Roanoke, and Pulaski, in Virginia; from Knoxville to South Pittsburg, in Tennessee; and at all points where pig iron can be made to advantage in Alabama and Georgia. It is especially adapted to make steel from the pig iron made at Bessemer, Birmingham, and Sheffield, Alabama.

THE NEW COLT CARTRIDGE PACK,

For Loading all Chambers of a Revolver Simultaneously.

The records of the Patent Office show that ever since revolvers came into general use by Colonel Colt's inventions, efforts have been made to devise some means by which the chambers in the cylinder of a revolver could be loaded and reloaded without necessitating the tedious operation of introducing each separate charge singly into the corresponding chamber of the cylinder. This was especially desirable when, before the introduction of fixed ammuni-

tion, the powder charges had to be each separately measured and poured into each chamber, after which a bullet had to be rammed in front of every charge, and a percussion cap set upon the cone of each chamber. These operations required, of course, considerable time and deliberateness, and were quite out of question when, in the excitement of a fight at close quarters, the revolver came into play. The patents of that period show a number of pouches for carrying the separate powder charges and bullets, with means for facilitating the loading, and also some devices by which the cylinder itself, after being emptied, could be replaced by others, carried for this purpose in loaded condition in a convenient pocket or belt. The first step in the right direction was the introduction of packages containing as many cartridges as the cylinder had chambers, and each cartridge consisting of a powder charge and a bullet wrapped in an envelope of inflammable paper. Then finally the fixed ammunition was invented, where powder, bullet and primer are all held by the metallic cartridge shell. These metallic cartridges are a very great advance from the loose ammunition and from the paper envelope cartridges, and their use requires much less time and care than the latter, even in those revolvers where the cylinder is not removable for ejection of the shells and for reloading, and in using which, therefore, after each shell has been separately ejected, each chamber must be in the same manner reloaded.

The present time, however, has seen the introduction into more general use of revolvers which are constructed for the utmost rapidity of fire, and for this reason are provided with self-cocking locks and with simultaneous ejection. The newest (and best) of this class is the Colt's new 38-caliber revolver, adopted by the U. S. Navy Department; this pistol, while retaining the solid frame of all modern Colt revolvers, allows the cylinder to swing out of the frame laterally, and in this position all the emptied cartridge shells are simultaneously ejected by means of a very simple, but strong and efficient, ejecting device, and the chambers are presented for reloading.

With these facilities for rapid firing and simultaneous ejection, it could not fail that some better means for reloading would again be called for, because in cases where, after emptying the chambers, it should become necessary to reload so as to be able to continue the firing, the loading of each chamber singly with cartridges carried in a belt or pouch would require more time than the firing of all cartridges in the cylinder and the ejection of the shells would require collectively; so that the rapidity of a sustained revolver firing depends mainly on the facilities for reloading. It is therefore apparent that under circumstances where a second or third charge of the revolver may become decisive, that an enormous advantage would rest with that side who could reload most rapidly and thus continue its fire.

These considerations led to urgent calls for reloading devices, from officers both of the navy and of the army; and General J. C. Kelton, the present Adjutant-General of the U. S. Army, realizing their necessity, wrote in an article entitled "Devices by means of which effective mounted firing with the pistol and carbine can be obtained, by cavalry in attack," published in the Journal of the U. S. Cavalry Association, of March, 1888, as follows: "Such a pack for certain and rapid reloading is absolutely necessary in war, and especially where the pistol is used in hand-to-hand combat, where success depends upon the rapidity with which it can be reloaded and discharged." The same distinguished officer also invented and patented several cartridge packs for reloading revolvers.

Closely following these appeared the Colt cartridge pack, which is an improvement on all prior ones, as it consists of fewer parts and requires much less expertness in its use. This pack was patented in the United States on April 30th, 1889, and its merits are so evident that it was at once adopted and a large number ordered by the U. S. Navy Department for use with the new Colt navy revolver.

The accompanying cuts show the pack and the mode of using it; one of the lower figures on the left represents the entire pack, holding six cartridges, and those on the right show separately the two parts, the ring and the plug, which with the cartridges constitute the pack. The large central figure shows the pack in use for reloading a revolver; the left hand of the operator holds the 38 Colt revolver with its cylinder swung out, presenting all the chambers, while his right hand applies the cartridge pack, by grasping the ring and pushing it towards the cylinder, thus forcing the cartridges into the chambers, while the plug is allowed freely to escape rearward. The outside figure on the left represents an auxiliary implement, the charging block, which serves to assist in assembling the packs before they are served out to the sailors or soldiers. While the assembling can be done without the block, it is done much easier and quicker with it; this is effected by simply depositing the six cartridges with their bullets in the corresponding six holes in the block, then placing the ring over the heads of the cartridges, and introducing the plug from the top through the central opening in the ring, between the cartridges, and firmly pressing it home until its top flange rests near or on the heads of the cartridges, when the complete pack may be removed from the charging block. The cartridge heads are each firmly held by a shoulder under the flange of the plug, and pressed outward into the corresponding recess in the ring below its flange; and while the tapering sides of the ring confine the cartridges at the proper angle, the lower part of the body of the plug wedges the cartridges outward at the end of the cartridge shells, without touching the bullets, thus avoiding any disfiguring of these. The bullets, as also the tapering end of the plug, are thus held in the proper position to correspond with the chambers and the central hole in the rear face of the cylinder. As long as the plug remains in the described position between the cartridges, the pack holds firmly together and will withstand quite rough handling without starting apart. When the pack is placed against the rear of the cylinder, each bullet readily finds its chamber,

and the end of the plug enters the central recess. On pressing now against the ring, without touching the plug, the cartridges enter gradually into the chambers, and the plug, resting with its point against the bottom of the recess, protrudes rearward from the ring; when sufficient of this motion has freed the cartridge heads from the shoulder under the flange of the plug, the cartridges are no longer held at an angle, but become parallel to the axis of the cylinder, as the smaller diameter of the plug body, below the shoulder, allows the cartridge heads to move inward and escape from the recesses in the ring; under the continued pressure against the ring, the cartridges fully enter into the chambers, while the plug drops out at the rear, and the empty ring may be removed.

Thus one single movement suffices to load all six chambers, and this can be done, in fact, even more quickly than a single cartridge can be loaded into its chamber; as it is much easier to remove the pack from its seat in the pouch and use it as above described, than to pick the comparatively small single cartridge from a pouch or belt and guide it to and introduce it into the chamber. Particularly is this the case at night time, for while after a very little practice it is easy to use the pack with the pistol in the dark, the same is quite difficult when single cartridges have to be used.

It has thus been shown that the rapidity of revolver firing really depends on the speed of the reloading, and with the Colt cartridge pack the interval necessary for reloading is so slight that the revolver becomes equal in the rapidity of its fire to a magazine arm with a large number of cartridges in the magazine; the reloading pack stands in fact to the pistol in the same relation as a detachable magazine to a rifle. A revolver provided with an ejector can only attain its best results when accompanied by a reloading pack; for the advantage of the simultaneous ejection of the shells is of small value if not followed by an equally certain and rapid reloading. The new pouches for the U. S. Navy are arranged to hold several of the packs ready for instant use, the charged packs being served out to the men instead of loose cartridges, and one charging block accompanies every 100 packs.

For cavalry use this pack is excellent, for the trooper can readily use his right hand to load with the pack, while holding the open pistol in his left or bridle hand.

The rings of the pack, being struck up of brass, may be refilled any number of times, as they do not suffer any change from being used; the plugs, being wood, may be used repeatedly, though long continued use will finally reduce their diameter at the points where the cartridges bear against them, enough to make their replacement by new plugs necessary. However, while at drill, rings and plugs may be saved for recharging; their price is so small that their loss in action will be no more expensive than that of the cartridge shells.

As pistol shooting has of late become very popular, those who practice it with ejecting revolvers may save themselves much useless trouble by supplying themselves with and using these reloading packs. They may be safely carried charged in a pocket, or with the block they can be charged at any convenient time. A lower part may be added which covers the bullets and cartridges and slides on to the ring from below, thus forming a perfect box around the cartridges; but this is not essential, and is not done in military use. While the pack shown only fits the six-shot Colt 38 revolver, other ejecting revolvers, which present the rear face of the cylinder when open for the use of the pack, can be reloaded in the same manner; and the packs can be made for any number of cartridges, corresponding to that of the chambers in the cylinder of the pistol.

COLT'S ARMORY, HARTFORD, CONN., *July* 31, 1889.

ON THE RELATION OF THE YARD TO THE METER.

Bulletin No. 9 of the United Coast and Geodetic Survey contains the results of an investigation of the sources of the discrepancy in the values assigned to the ratio of the yard to the meter, made by O. H. Tittman, Assistant U. S. Coast and Geodetic Survey, in charge of weights and measures. The following interesting table is taken from the Bulletin. The third column contains the values of the meter expressed in inches, but referring to different metric and British units. The last column gives the results of the comparisons as reduced by Mr. Tittman, to the Committee Meter, C. M., in terms of the Imperial Yard.

Date.	Authority.		
1817–32	Hassler,	39.380917	39.36994
1818	Kater,	39.37079	39.36990
1835	Baily,	39.369678	39.36973
1866	Clarke,	39.370432	39.36970
1885	Comstock,	39.36985	39.36984
	Indiscriminate mean,		39.36980

BIBLIOGRAPHIC NOTES.

BULLETIN OF THE AMERICAN GEOGRAPHICAL SOCIETY.

VOLUME XXI, No. 1, MARCH 31, 1889. Among the natives of Australia. The Portuguese in the track of Columbus. The Rio San Juan de Nicaragua. The Russian traveller Prjevâlsky.

No. 2, JUNE 30. The Hawaiian Islands. The Portuguese in the track of Columbus. The Great Basin.

DEUTSCHES HEERES-ZEITUNG.

MAY 22, 1889. Gun trials at the Gruson works.

MAY 29. Wire guns. A. G.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

VOLUME VIII, No. 4, APRIL, 1889. History of a high viaduct. Wrought iron and steel eye-bars. The Quaker bridge dam. Smoke prevention. Recent improvements in electrical transmission.

No. 5, MAY. Some tests of full size angle irons. The winding of dynamo fields. Rapid transit in Boston. Legislative control of railways.

No. 6, JUNE. Cable conduit yokes. Erection of iron bridges. San Blas canal *vs.* Panama canal. Engineering. Water supply tests by the use of pressure gauges.

JOURNAL OF THE FRANKLIN INSTITUTE.

FEBRUARY, 1889. The Nicaragua canal. Spirally-welded steel tubes. Some American contributions to meteorology.

MARCH. The transmission of power by electricity. Some American contributions to meteorology.

APRIL. Fire Island Inlet. The transmission of power by electricity. Differential method of computing apparent places of stars for latitude work. Spacing the ellipse. An investigation of some experiments on a centrifugal blower delivering air into the atmosphere at large.

MAY. Amateur photography in its educational relations. The manufacture of Bessemer steels.

JUNE. A contribution to meteorology. The diffraction of sound.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XVII, Nos. 3 and 4, 1889. The reorganization of the English fleet. The development of naval wars; an historical sketch. Budget of the Imperial German navy, 1889–90; same, French navy. Course of instruction in torpedoes, gunnery, and navigation in the English navy. Report of the committee on the English squadrons of evolution. Trial of Schneider plate in Sweden. Experiments with bellite. American cast-steel guns. Dynamite guns for U. S. coast defense. A new rapid fire gun (Armstrong 6-in. R. F. G). Cresilit. Dynamite shell. English armored ship Victoria. French armored ships Courbet and Formidable. New gunboat of the first class for Norway. English torpedo vessel Spanker. English cruiser Barrosa. Tests of the water-tight compartments in the ships of the Italian navy. The pneumatic yacht Eureka. Buoyant woodite and Mr. Brewster's cork substance. Life boat with hydraulic propulsion. Parsons' turbine dynamo. Ship-building in England in 1888. Submarine cables of the world. The geographical societies of the world. Torpedo boat with creosote fuel.

Nos. 5 and 6. The expenditure of ammunition in ship guns in an attack on fortresses, and the supply of ammunition for coast defense guns. Nautical calculations of the time of high water. Alternative project for the new English battle-ship of the first class. Seaworthiness of torpedo boats. Dangers in working engines on board ship. Budget of the English navy for the year 1889–90. Cause of the sinking of both French torpedo boats Nos. 102 and 110. U. S. dynamite cruiser Vesuvius. Ventilation on the Formidable. Extracts from the official reports of the trials of the dynamite guns in North America. The Resistance experiments. A new monitor cruiser. Armored ship for coast defense of the United States. Launch of the ram cruiser Francis Joseph I, Austrian-Hung. navy. The Italian cruiser Piedmont. Prizes for officers in the Royal Naval School at Greenwich. Schichau's new ship yard at Danzig. Hengst's smokeless powder. A new musket. New musket powder. Smokeless powder in England. Gatling's torpedo boat. New 28 cm. gun for the Pelayo. Harbor forts at Spezzia. Trials with Maxim guns. War ships launched in 1888. Speed trial of the Medusa. Telegraph school for the German imperial navy. Suez canal in 1888. Effect on chronometers of firing. A. G.

NORSK TIDSSKRIFT FOR SOVAESEN.

7TH ANNUAL SERIES, No. 4. How can collisions at sea be avoided (after the French by Capt. M. Banaré). Remarks on Capt. O. Hansen's prize essay: Necessary strength of army and navy and armament required for coast defenses of Norway and Sweden, by Col. Gerster. Annual review. Necrology. Minor articles: Bombardment of open harbors; Howell torpedo; Life-boats of the City of New York; Currents in the North Atlantic; Trials with torpedo-

boats; Bursting of the guns on board the French ironclad Amiral Duperré.

No. 5. How can collisions at sea be avoided (continued). Remarks on Capt. O. Hansen's prize essay: Necessary strength of army and navy and armament required for coast defenses of Norway and Sweden, by Col. Gerster (continued). Cruises of the vessels of the Norwegian navy, 1888. Use of polar star in navigation. Literary review. Minor articles: Cellulose; The American dynamite cruiser Vesuvius; The largest mail steamers; The German navy; The Italian armor-clad Re Umberto.

E. H. C. L.

REVUE DU CERCLE MILITAIRE.

APRIL 21, 1889. The actual rôle of fortified places, according to General Purron (ended); see No. 15 of the Review of April 14, 1889, p. 329. Ways and means of communication in Tonkin (with diagrams in the text). Military chronicle: Letters from the United States, Italy, etc.

APRIL 28. On counter-attacks and the assuming of the offensive. Ways and means of communication in Tonkin, with diagrams (ended). The European armies. Industrial processes available in the army; photographic receipts.

MAY 5. The moral education of the soldier in the Russian army. About counter-attacks and the assuming of the offensive. Military dove-cots.

MAY 12. Field observations (with plates in the text). Samoa Islands and the German-American conflict. Military dove-cots (ended). Foreign military chronicle: Letter from United States, etc.

MAY 19. Temporary field fortifications. The rights of nations in war times. Opinion of Vauban on privateering. Foreign military chronicle.

MAY 26. The German regulations for field artillery tactics of March 25, 1889.

It is a new manual of field artillery, very much simplified.

Temporary field fortifications (ended). A new gun of 320 millimeters, Bange system.

The gun was made for the Paris Universal Exposition, and was tested at the proving grounds of the trial committee at Calais. Here are the principal dimensions of the new gun: Length of the piece, $12^{m}.50$; total weight, 47 tons; weight of the projectile, 400 kilos; muzzle velocity measured by the Le Boulengé chronograph, 650 meters; velocity at 1500 meters measured by the Le Boulengé chronograph, 590 meters; range measured at an angle of 10 degrees, 9500 meters; maximum range, 19,000 meters; thickness of the iron plate pierced by the projectile at the muzzle, 90 centimeters; thickness of the iron plate pierced by the projectile at a distance of 1500 meters, 75 centimeters; thickness of the steel plate of the greater resistance pierced by the projectile at the muzzle, 60 centimeters; at 1500 meters, 50 centimeters; energy at the muzzle, 8622 meter-tons; height to which this force could raise the gun, 183 meters.

The new French manual of infantry manœuvres. Title IV, school of battalion. The cavalry armament as viewed by an officer of high rank in the Egyptian army. The musket model, 1886.

Experiments to determine the perforating power of this gun, made at Gavre (the French proving grounds) in June and July, 1888, gave the following results (the table shows the thicknesses of the sundry obstacles stopping the progress of the bullet at various distances). Distances, 10 m., 200 m., 500 m.

	Centimeters.		
Pressed coal dust (brignettes) . .	22	30	40
Ordinary coal, ...	10	15	30
Sand, ...	11	45	40
Earth, ...	25	45	40

At 10 meters the coal, sand and earth presented great resistance to penetration. It was also noticed that at that distance the bullets underwent considerable deformations. Penetration increases with the distance; at 200 meters it is greater and the bullets are not deformed; at 500 meters penetration is generally more feeble. It therefore seems to decrease with the force of impact, but only reckoning from a given distance.

This anomaly is owing, apparently, to the irregular rotations that take place on leaving the muzzle.

In the case of other obstacles penetration follows a regular law, increasing with the velocity at the impact, as shown in the following table. Distances, 10 m., 40 m., 200 m., 500 m.

	Millimeters.			
Pine, ...	900	..	600	150
Oak, ...	200	..	280	150
Sheet iron, . . .	12	..	6	4
Sheet of soft steel, . .	10	9	4	2
Sheet of chromed steel, .	..	4	..	..

From the above results, the gun mod. 1886 possesses a perforating power much superior to that of mod. 1874, firing the regulation bullet, or even a hardened lead bullet, at short distance, but this superiority disappears notably as the distance increases.

JUNE 9. Production of and advantages derived from artificial clouds in battle. The firing of dynamite shells. The pneumatic gun in the United States and Germany. The Maxim gun (a detonating gaseous mixture). Steam guns. Hicks' projector (with descriptive plates in the text). Processes in use for the reproduction of drawings; a few elementary receipts. Projected formation of a railroad regiment (5th Engineer).

JUNE 16. The rôle of cavalry with respect to the other arms of the service. Production of artificial clouds in battle. The firing of dynamite shells (ended). Industrial processes available in the army.

JUNE 23. Routine *versus* improvements in military regulations. The siege of Ba-Dinh, Tonkin (1886–87). Holland and her flooding system. The army exhibit at the Exposition. Military chronicles. Hygiene in the army.

JUNE 30. Moral education of the soldier; the regimental surgeon as a military educator. The seige of Ba-Dinh, Tonkin (1886–87). The military exhibit at the Exposition of 1889 (con-

tinued). Military chronicle. The obsequies of Chevalier de Langle, the companion of Lapérouse. J. L.

REVUE MARITIME ET COLONIALE.

MAY, 1889. Tourville and the navy of his time, with notes, letters, and documents [1642–1701] (ended). Historical notes on the Gavre committee. Scientific mission to Cape Horn; meteorology. The Gulf of Gabes (Tunis) fishery (ended). Foreign chronicle: Reorganization of the admiralty in Germany. The personnel of the reserve (England). Approval of the new programme of the fleet. Description of the auxiliary cruisers Majestic and Teutonic. Trials of the gunboat Pigmy. Launch of the gunboat Lapwing. Tests to which vessels will be submitted coming out of the reserve. Ships to be condemned during the next five years. Trials of the gunboat Yorktown, U. S. N. High-powered guns for the English coast's defenses. The Hontoria guns. J. L.

ROYAL ARTILLERY INSTITUTION.

VOLUME XVII, No. 2. On the vertical "drift" of elongated projectiles. Signaling as applied to field artillery. Military ballooning. Quadrant elevation for naval ordnance.

No. 3. Machine guns and their employment. Siacci's method of solving trajectories and problems in ballistics. Notes on 2.5-inch gun. Notes on the United States dynamite-gun cruiser Vesuvius and her armament. A descriptive history of quick-firing guns.

ROYAL UNITED SERVICE INSTITUTION.

VOLUME XXXIII, No. 147. Quick-firing guns for fortress defense. The Royal Naval Reserve. On coaling ships. The more recent improvements in the Thornycroft torpedo-boats. The relations between local fortifications and a moving navy. Our naval position and policy. The campaign in the North Sea and the Baltic.

No. 148. The unprotected state of British commerce at sea.

UNITED SERVICE GAZETTE.

JUNE 1, 1889. The tactics of coast defense. The escape of the Calliope. The loss of the Sultan; court of inquiry. The mariner's compass in modern ships of war.

JUNE 8. A year of lifeboat work. The loss of the Sultan; court of inquiry. The Royal Naval Artillery Volunteers.

JUNE 15. The position-finder.

JUNE 29. The naval volunteers. The training of German and French naval officers.

LE YACHT.

APRIL 20, 1889. Our new vessels building. Review of the merchant marine. The 3d-class cruiser Laland. New type of American barge.

APRIL 27. The Edinburgh. The value of the ram in a naval combat.

MAY 4. The naval manufactories at Creusot. The new English armored vessel of 14,000 tons. The value of the ram in a naval combat (cont.).

MAY 11. The navy. International maritime conference at Washington. The value of the ram in a naval combat.

MAY 18. The Italian cruiser Piemonte.

MAY 25. Review of the merchant marine.

JUNE 1. The English navy.

JUNE 8. The navy. The use of oil for quieting the sea. The Greek armored vessel Hydra.

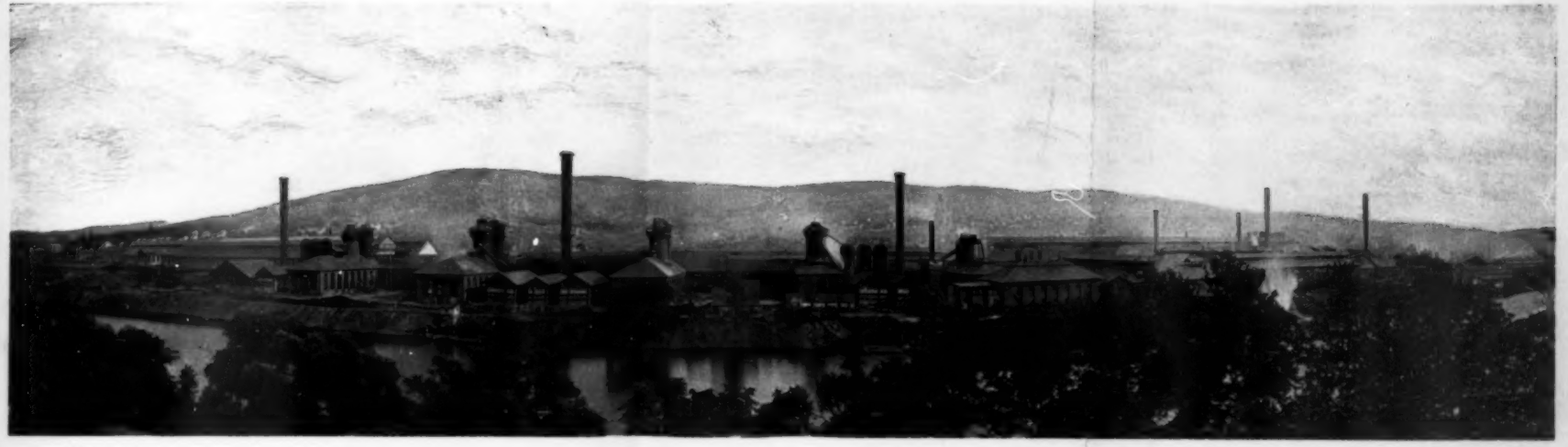
JUNE 15. Review of the merchant marine.

JUNE 22. Appropriations for the navy.

JUNE 29. Our naval manœuvres. The influence of speed in ramming collisions (cont.).

REVIEWERS AND TRANSLATORS.

Lieut.-Comdr. E. H. C. LEUTZÉ,
Lieut. J. B. BRIGGS,
P. A. Eng. F. H. ELDRIDGE,
Lieut. A. C. BAKER,
Lieut. A. GLEAVES,
Prof. JULES LEROUX,
Prof. H. MARION,
Prof. C. R. SANGER.



WORKS OF THE BETHLEHEM IRON COMPANY,

SOUTH BETHLEHEM, PA.

1889.